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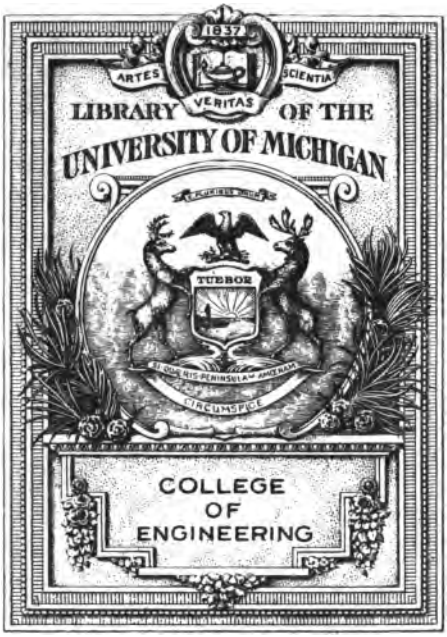

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CONCRETE WORK

A BOOK TO AID THE SELF-DEVELOPMENT OF WORKERS IN CONCRETE AND FOR STUDENTS IN ENGINEERING

BY

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VOLUME II

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AND
WALTER C. VOSS

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PREFACE TO VOLUME II

Scientific principles are rapidly being applied to the increasing volume of concrete construction. An urgent need exists for the training of inspectors and workers who will have an understanding of the laws controlling the handling of concrete.

This volume is prepared to develop the **practical ability** of the concrete worker, the inspector, and the student in technical schools. This ability is best developed through the actual **doing** of jobs, learning the "how" and the "why" of these. Volume I is a reference book for Vol. II.

Most of the applications of concrete are founded on a few fundamental principles and operations, of computing, selection of materials, mixing, and placing concrete. The "job" sheets in this volume are devised to uncover these fundamentals. Once these elementary elements are understood, subsequent applications in diverse constructions may be handled intelligently, and practices may be modified to suit new situations.

It is the intention to lead the worker and student through the work of reading blue prints; calculation of quantities; estimation of cost; selection and inspection of materials; selection and disposition of equipment; organization of gang; staking out; excavating form work; measuring, mixing, and depositing concrete; protection of work — in a word, what a **foreman** on a small job must be able to do, or the work of a **local cement contractor or inspector.** The field of the **engineer** is not reached. This book fills in a gap between the theory of the engineer and the special technology of the contractor.

384022

The job sheets may be conveniently classified into: elementary operations; tests of materials; inspection of construction; construction methods; study of materials and methods; experiments; information.

Some of these jobs are best handled in a school laboratory, where testing machines and other apparatus are available. Indeed these jobs will all be profitable for a student in engineering as a basis for advanced work. Most of the jobs can be carried out in the shop or yard. Some of them are best handled by the co-operation of two or more workers.

The jobs may be followed through in connection with a construction under way. However, the conditions of contract work do not permit interruption for examination and questioning. It is better, therefore, to make a special business of this study by doing the jobs one by one.

Most of the elementary jobs were performed by men, who had little preparation in the way of experience or schooling, in connection with the training of Concrete Workers in the Vocational Detachments of the U. S. Army at Purdue University. One of the authors, (W. K. H.) afterwards developed these in a Manual at the instance of the Special Committee on Education and Special Training of the War Department. The present Volume II is an extension of this Manual. Job Sheets Nos. 7 and 8 contain problems which were devised for the Training Detachment at the University of Wisconsin in charge of Professor Withey.

The job sheet involves: a title; a direction or order to do a certain thing; a series of development questions, not to be answered after the job is complete, but to direct the thought of the worker and to bring him to his own decisions from time to time upon the situation as it confronts him in the progress of the job. Such decisions are reached by thoughtful consideration of the facts and by reference to information in text books and catalogues. The student's progress will, of course, be aided by an instructor; but the student should think out, and not be given, at once, the answer to a difficulty. The necessity of **careful observation** of the happenings during the job will be evident. One end to be reached is the habit of the worker to reach decisions on carefully determined facts, and a desire to **test things out.**

The job sheets Nos. 80 to 83 which aim to develop a sense of the mechanical action of columns, beams, and slabs may be unnecessary to many. They will show where bars should be put in concrete, in simple cases, and should prevent mistakes that have occurred in construction.

The sequence of the job sheets is not always logical. The numbering is not consecutive, but permits of addition within groups.

The word "job," used so many times in the volume to denote something to be done, has recently come into common usage, is convenient, and will cause no confusion. In general, words which will be familiar to the concrete worker have been chosen in preference to words more familiar to the academic ear. The authors have had many problems to solve in preparing a book in a new field, and have not avoided the colloquial when a purpose was to be served.

W. K. H.
W. C. V.

LAFAYETTE, IND.
BOSTON, MASS.
July, 1920.

CONTENTS

SECTION		SHEETS	PAGE
I.	DRAWING AND COMPUTING	1–9	1
II.	PRELIMINARY TO CONSTRUCTION	11–17	18
III.	INSPECTION, PROPORTIONING AND TESTS OF MATERIALS	20–52	29
IV.	FORMS	53–59	117
V.	MIXING CONCRETE	60–71	127
VI.	REINFORCED CONCRETE CONSTRUCTION	80–90	142
VII.	SIDEWALK CONSTRUCTION	100–107	161
VIII.	PRODUCTS	110–113	176
IX.	WALLS, ETC	120–132	187

LIST OF JOB SHEETS

I. Drawing and Computing

No.
1. Practice the Use of the T-Square Triangle and Architects' Scale.
2. Draw Simple Objects in Projection.
3. Read Drawing of Concrete Steps.
4. Draw Stepped Footing.
5. Draw Section through Coal Chute.
6. Compute the Arithmetical Problems Listed.
7. Calculate Areas.
8. Compute Quantities of Material.
9. Read Drawings of Building.

II. Preliminary to Construction

11. Determine the Output of Laborers in Shoveling, etc
12. Stake out a Foundation.
13. Brace a Trench.
14. Build a Cement Storage Shed.
15. Construct a Mixing Platform.
16. Construct a Measuring Box and Calibrate Tools.
17. Construct a Home-made Testing Machine.

III. Inspection, Proportioning and Tests of Materials

20. Sample a Car of Cement.
21. Test Cement.
22. Test of Sand for Cleanness.
23. Measure Voids in Aggregate.
24. Test Aggregate for Weight per Cubic Foot.
25. Study Sieves.
26. Curve Plotting.
27. Test Gradation of Aggregate by Sieving.
28. Specifications for Aggregates.
29. Changes in Volume of Aggregate.
30. Yield of Concrete and Quantities Required.
31. Sample and Report on a Gravel Pit
32. Mix a Batch of Concrete by Hand.

33. Theory of Concrete.
34. Water Required for Mixing.
35. Consistency of Concrete.
36. Strength of Concrete of Various Proportions.
37. Proportions Recommended from Different Classes of Construction.
38. Strength of Concrete of Different Consistencies.
39. Strength of Mortar Made of Fine and Coarse Sand.
40. The Proportioning of Concrete Mixes.
41. Proportioning of a Gravel Concrete.
42. Test Proportioning by Void Measurement.
43. Test Proportioning by Arbitrary Mix.
44. Test Proportioning of Bank Run Gravel.
45. Proportioning by Surface Area.
46. Proportioning by Fineness Modulus.
47. Test the Bond Strength of Steel in Concrete.
48. Test the Strength of Anchorage by Hooks and Bends.
49. Study the Forms of Various Samples of Deformed Bars.
50. Test Reinforcing Steel for Bending.
51. Study Concrete Fabric Reinforcement.
52. Study Nails.

IV. Forms

53. Study Lumber for Forms.
54. Estimate Form Lumber.
55. Study Tools and Machinery for Wood Working.
56. Form Details for Plain Concrete Stairs.
57. Build a 2-Wall Form.
58. Study Assembly of Forms and Details for Lawlor Building.
59. Draw up Assembly and Panel Details for Stepped Footing.

V. Mixing Concrete

61. Make Template for Dowel Placing.
62. Construct Machine Base and Set Anchor Bolts.
63. Place Dry Concrete in Wall Foundation.
64. Mix a Batch of Concrete by Machine.
65. Correct Mix when not normal.
66. Study Catalogues of Concrete Mixers.
67. Place Wet Concrete in Wall.
68. Build Stop Board in Wall Form.
69. Construct a Coal Chute.
70. Bond New on Old Concrete.
71. Study Waterproofing of Concrete.

VI. Reinforced Concrete Construction

80. Study Reinforcing of Columns.
81. Determine where Tension Occurs in Beam.
82. Determine the Proper Location of Reinforcing Rod in Beam at Center.
83. Determine the Location of Reinforcing at the End of a Beam.
84. Read the Drawing of Slab Reinforcing.
85. Read the Drawing of Beam Reinforcing.
86. Study Details of Beam No. 7.
87. Construct Skylight Curb, and Place Wooden Curb Plate.
88. Build Expansion Joint in Roof Beam.
89. Bend Reinforcing Rods.
90. Construct a 1-Way Tile and Joist Slab.

VII. Sidewalk Construction

100. Organization of Sidewalk Job.
101. Stake out Sidewalk, Excavate, and Build Forms.
102. Set up Level Instrument and Read Level Rod.
103. Set Curb Stakes with Level Instrument.
104. Construct a Sidewalk Base.
105. Finish and Place the Top.
106. Construct Section of Curb and Gutter.
107. Proper Curing of Concrete.

VIII. Products

110. Cast a Sill and Finish It.
111. Construct a Post over a Parapet Wall.
112. Sand Cast Artificial Stone.
113. Plastering.

IX. Walls, etc.

120. Build a Brick Wall and Set Door Frame.
121. Erect a Tile Wall and Door Frame.
122. Study Steel Sash.
123. Build Wood Partition and Set Metal Sash.
130. Estimating.
131. Estimate Steel in Roof Sash.
132. Study Construction Plants.

INFORMATION

Much profitable information will be found in the following pamphlets, copies of which may be had free of charge by addressing the Portland Cement Association, 111 West Washington Street, Chicago:

Concrete Silos.
Portland Cement Stucco.
Concrete in the Country.
Farmers' Handbook on Concrete Construction.
Concrete Swimming and Wading Pools.
Concrete Linings for Irrigation Canals.
That Alley of Yours.
Concrete Houses and Why to Build Them.
Fundamentals of Reinforced Concrete Design.
How to Maintain Concrete Roads and Streets.
Recommended Specifications for Reinforced Concrete Design.
Suggested Specifications for Concrete Floors.
Why Build Fireproof?
Integral Curb for Concrete Pavement.
Cement Stave Silos.
Concrete Tile for Land Drainage.
Protecting Concrete in Warm Weather.
Concrete Grain Bins and Elevators.
Bulk Cement.
Concrete Ships.
Facts Every One Should Know about Concrete Roads.
Standard Specifications and Tests for Portland Cement.
Specifications for Concrete Roads, Streets, and Alleys and Paving between Street Car Tracks.
Concreting in Cold Weather.
Tennis Every Day on Concrete Courts.
Concrete Septic Tanks.
Concrete Fence Posts.
Small Concrete Garages.
Concrete Facts about Concrete Roads.

Concrete Feeding Floors, Barnyard Pavements and Concrete Walks.
Proportioning Concrete Mixtures and Mixing and Placing Concrete.
Concrete Foundations.
Concrete Troughs, Tanks, Hog Wallows, Manure Pits, and Cisterns.
Concrete Sewers.
Proportioning and Mixing Concrete.
Manual Training Course in Concrete.
Colorimetric Test Bulletin.
War Uses of Concrete.
Concrete Pressure Pipe.
Equipment for Concrete Road Construction.
Concrete Highway Bridges.
Recommended Practice in Constructing Highway Bridges.
Concrete Foundations.

FOREWORD

To me this is a most interesting and fascinating textbook. Many text writers appeal wholly to the reader's thought, and many teachers are satisfied with a good memory on the part of their students. But here the authors stimulate one to action. After reading a job sheet, you will desire to hunt up an old shovel, get a bag of cement, go to the gravel pile, and work out an understanding of the theory so clearly suggested between the hundreds of lines of questions.

Often the simplest scientific facts are shrouded in technical terms, to the dulling of the youth who is tingling for action. To try, to experiment, to discover, to venture — these are in the blood; and in the field of concrete we have here a guidance and not a repression. The questions, problems and jobs suggested are so shaded from simple to complex that the underlying scientific principles are readily discovered and assimilated. But as essential as correct scientific information is, the great value of the book lies in its stimulation — in the development of originality, initiative, judgment, sense of responsibility and a proper perspective in doing a practical job scientifically.

The truth of the matter is — such a text in the hands of an inspiring teacher will not only *teach the technique of concrete*, but will *develop men*, because it is humanly interesting and stimulating from cover to cover. This is as life was meant for us all, especially the youth even when going to school. The "do" and the "how" and the "why," practiced and studied together, are stimulating — taken separately they are dull.

Those who have the responsibility of developing leaders will be vitally interested in these books.

C. R. DOOLEY.

March 1, 1921.

CONCRETE WORK

SECTION I

DRAWING AND COMPUTING — Sheets 1–9

Job Sheet No. 1

VOL. I, CHAP. II, PAGE 11. FIGS 1–4

THE USE OF THE T-SQUARE, TRIANGLE AND SCALE. PRACTICE THE USE OF THE T-SQUARE, THE 45-DEGREE AND THE 60-DEGREE TRIANGLE AND SCALE
USE A 2 H PENCIL

1. Tack on the drawing board a piece of drawing paper, 12 inches by 18 inches in size.

2. The edge of the paper should be parallel to the blade of the T-square. Why?

3. The T-square head should fit snugly against the left-hand edge of your board. Why?

4. Sharpen the pencil.

5. What are the angles of your two triangles? Why do we call one a "45-degree triangle" and the other a "30- by 60-degree triangle"?

6. Which of the two tools, the triangle or the T-square, should you use to draw horizontal lines? Which for vertical lines?

7. Draw a square, 6 inches on the side.

8. Draw the diagonals of the square with a 45-degree triangle.

9. These diagonals should meet the four corners of the square.

10. With the T-square and the triangle draw lines parallel to the sides of the square through the intersection of the diagonals.

11. These lines should divide the sides of the square into two equal parts.

12. Draw a line 8 inches long with the T-square. Draw from this line:

(*a*) A line at right angles, 4 inches long.
(*b*) A line at 60 degrees, 3 inches long.
(*c*) A line at 30 degrees, 5 inches long.

13. How many scales are there on the ordinary triangular architect's scale?

14. Draw a line 8½ inches long to represent the center of a road.

15. Apply an architect's scale to this line and record how many feet and inches of length of road this line represents, if each foot of length of road is represented by:

(*a*) 1 inch of paper. Scale 1 inch to the foot.
(*b*) ½ inch of paper. Scale ½ inch to the foot.
(*c*) ¼ inch of paper. Scale ¼ inch to the foot.

16. Draw a line at right angles with the line in question 10, and lay off on this line a length to represent a distance of 10 feet on the following scales:

(*a*) 1½ inch equals 1 foot.
(*b*) 1 inch equals 1 foot.
(*c*) ⅛ inch equals 1 foot.

17. Draw a line 10 inches long with the T-square and lay off lengths to represent distances of 3 feet 6 inches; 13 feet 9 inches; 21 feet 2 inches to a scale of ¼ inch to the foot.

Job Sheet No. 2

VOL. I, CHAP. II, PAGE 14. FIGS. 6 AND 7

MAKE PROJECTION DRAWINGS OF SIMPLE OBJECTS

The method of drawing objects in projection is shown in Fig. 1. The top figure is the solid view of the sill as seen inside a hollow box. The projections of the sill, that is, the sill as seen when it is looked at from above (H), from the front (V), and from the side (S. V.) are shown on H, the top of the box; on V, the front of the box; and on S.V., the side of the box.

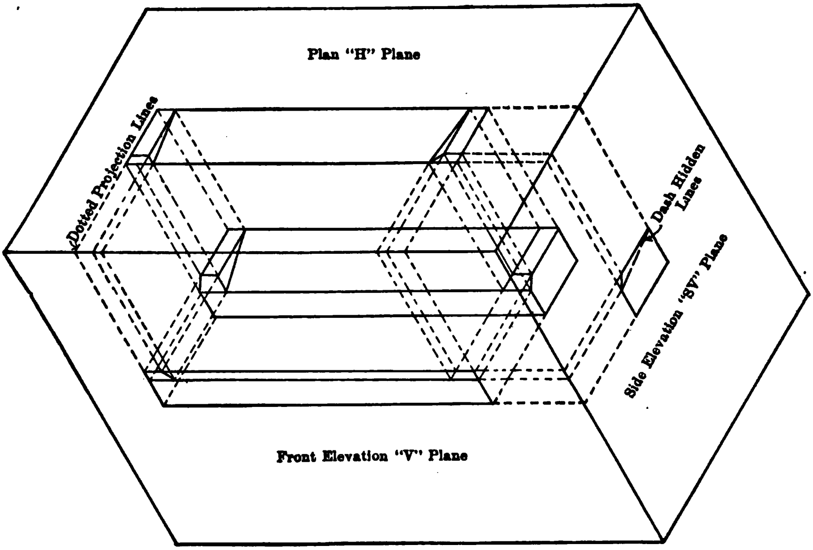


FIG. 1. METHOD OF SHOWING OBJECTS IN PROJECTION.

Figure 2 shows these three projections drawn in relation to each other on one sheet of paper.

1. Make projection drawings of the three objects, A, B, and C shown in Fig. 3.

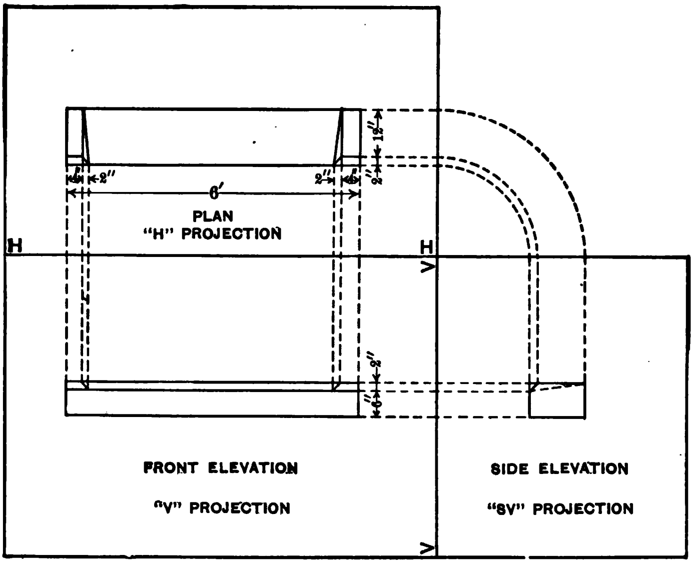
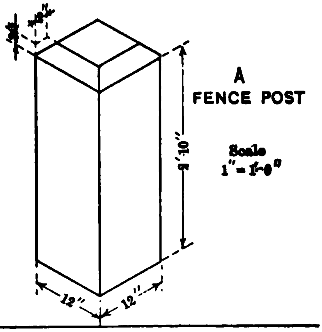


Fig. 2. Object shown in Projection.

2. Could a workman construct these objects from the information of your drawings?



B

Cast-sill Shown in Fig. 102—Vol. I

Scale ⅛"= 1' 0"

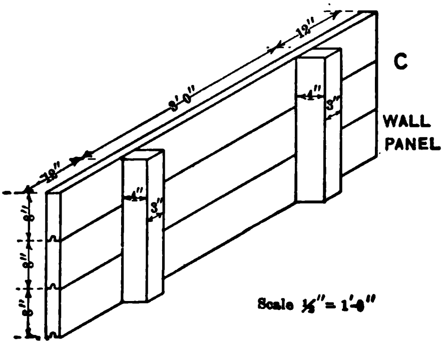


Fig. 3. Objects to be Drawn in Projection.

Job Sheet No. 3

VOL. I, CHAP. II, PAGE 8. PLATE I.

READ DRAWING OF CONCRETE STEPS

1. What does Fig. 4 represent?
2. What part of the Lawlor Building is it?

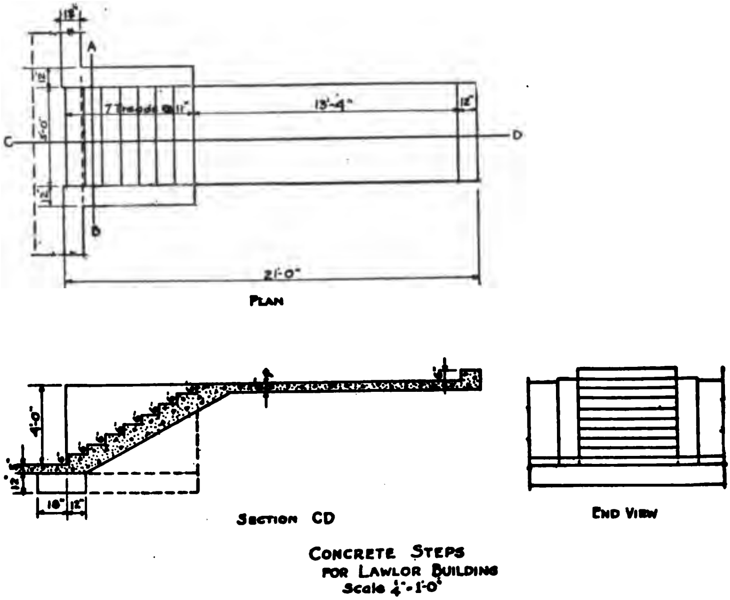


FIG. 4. DRAWING OF CONCRETE STEPS, LAWLOR BUILDING.

3. Locate the top view, section along line CD, and end view on Fig. 1.
4. Are these views in projection?
5. How can you tell?
6. How wide is the wall at top of the flight of steps? How long?

7. What is the total horizontal length of steps and walk?

8. What is the height?

9. How many steps are there from the ground to the top of the flight?

10. How high is each step? This is called the rise.

11. How wide is each step? This is called the tread.

12. In all three views in question (3) count the number of times the rise and tread of each step is shown.

13. What is meant by cross section? Locate a cross section on print drawn along line CD.

14. How thick is the side wall of these steps? The slab of the steps?

15. Draw a section along line AB.

NOTE. — The dash line in front view represents the top of the earth fill or the bottom of the mass of concrete.

Job Sheet No. 4

Vol. I, Chap. IV, Page 62. Fig. 29a

DRAW STEPPED FOOTING

Draw a stepped footing for Column No. 1, if dropped down 4 feet below grade of present column footing.

1. What depth will you make each step?
2. What projection will each step then have?
3. Ought we to allow a larger area for such a footing? How much more does this footing weigh? (1 cubic foot of concrete weighs 150 pounds.)
4. If the soil will carry 4000 pounds per square foot, how much larger will the area of the footing need to be?
5. What will be the elevation of the bottom of the footing?
6. How much more excavation is required?
7. Are more than two views necessary in the drawing to show the footing completely?
8. Would a plan and cross section through the footing give all the necessary information?
9. Draw a cross section.

Job Sheet No. 5

Vol. I, Chap. II, Page 8. Plates II and IV

CROSS SECTIONS

Draw a cross section through the coal chute 3 feet from the wall of the building. See Fig. 138, and Plates II and IV, Vol. I.

Note. — The student will submit the calculations of his dimensions to the instructors for criticism.

Job Sheet No. 6

ELEMENTARY ARITHMETIC

COMPUTE ARITHMETICAL PROBLEMS FOLLOWING:

1. A board 2 feet 6 inches long is to be sawed into 4 pieces of equal length. How many inches long will each piece be?

2. If a hundred linear feet of sidewalk is built in a day of 8 hours, how many linear feet can be built in $1\frac{1}{2}$ hours?

3. In doing a certain piece of work, one man puts in $1\frac{1}{3}$ hours, a second man $\frac{1}{2}$ hour, a third works $2\frac{1}{6}$ hours and a fourth man works $1\frac{1}{4}$ hours. How long will it take one man to do the work?

4. A gallon is about $\frac{2}{15}$ of a cubic foot. If a cubic foot of water weighs $62\frac{1}{2}$ pounds, how much does a gallon of water weigh?

5. I want to measure out $2\frac{1}{4}$ gallons of water but I have no measure. However, there are some scales handy and I proceed to weigh out the proper amount in a pail that weighs 1 pound and 14 ounces. What should be the total weight of the pail and water if one gallon of water weighs $8\frac{1}{3}$ pounds?

6. A pump delivers 2.35 gallons of water per stroke and makes 48 strokes per minute. How many gallons will it deliver in 1 hour?

7. I want 5000 feet of $\frac{3}{4}$-inch steel bars. A steel bar of this size weighs 1.914 pounds per foot. How many pounds must I order and what will be the cost at $4.15 per 100 pounds?

Percentage

8. A gang is cut down from 85 men to 62 men. What per cent of the original gang is retained?

9. The total weight of a dry mixture of concrete ma-

terials is 72 pounds, 4.3 pounds of water was used. What percentage of water was used?

10. There are 525 men in a vocational school. 20 of these are concrete workers. What per cent of the total number are concrete workers?

11. A cubic foot of water weighs 62.5 pounds. 24 pounds of water can be poured into a cubic foot of gravel. What is the per cent of open spaces or voids in the gravel?

Job Sheet No. 7

MENSURATION

COMPUTE THE AREAS CALLED FOR IN THE FOLLOWING EXERCISES (See Fig. 5)

Areas

1. The sides of the square columns in a building are 12 inches. Compute the sectional area in square inches.

2. A footing is 3 feet 4 inches by 2 feet 9 inches. Compute the area in square inches.

3. A triangular opening in a floor has one side of 12 feet 4 inches at right angles with another of 18 feet 5 inches. Compute the area of the triangle in square feet.

4. (*a*) The diameter of a circular sleeve through a concrete slab is 10 inches. Compute the area of the circle in square inches.

   (*b*) The radius of a circle is 10 feet 3 inches. Compute the area in square feet, and the circumference in feet and inches.

5. How many pounds of water in a cylindrical tank 10 feet in diameter if the tank has 10 feet of water in it? A cubic foot of water weighs 62½ pounds.

6. (*a*) A right-angle triangle has sides at the right angle of 3 and 4 feet in length. The third or slant side, called the hypotenuse, is computed by the following rule:

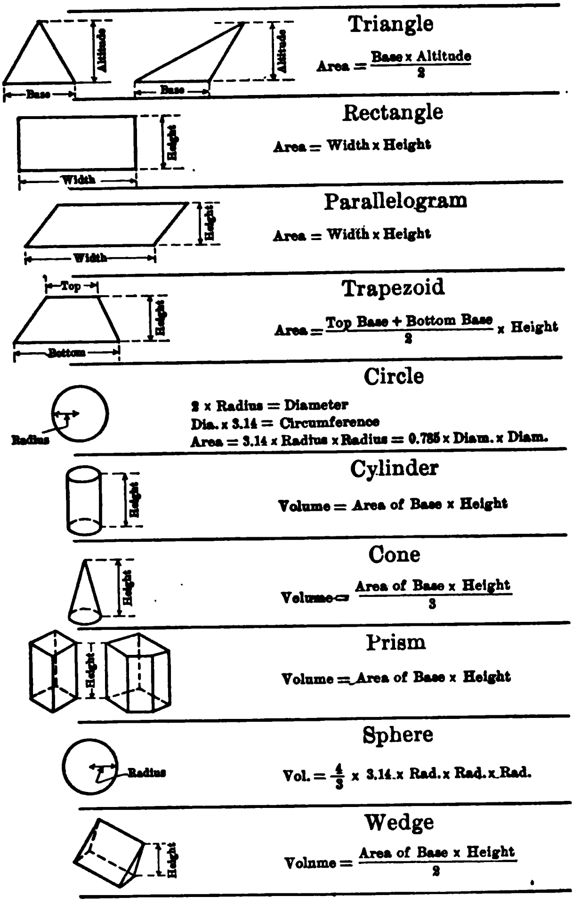
Add together the squares of the two sides at the right angle. Take the square root of the sum. The result is the length of the slant side. For example:

$$\begin{aligned} 3^2 &= 9 \\ 4^2 &= \underline{16} \\ & \ 25 \qquad \text{Square root of } 25 = 5. \end{aligned}$$

(*b*) Use a table of squares and square roots and find the length of the slant side when the two other sides are 6 feet and 10 feet.

(*c*) The sides of a right-angle triangle are 3, 4, and 5 feet, 6, 8, and 10 feet, 9, 12, and 15 feet, etc. Prove this by use of table of squares.

MENSURATION



Triangle

$$\text{Area} = \frac{\text{Base} \times \text{Altitude}}{2}$$

Rectangle

Area = Width x Height

Parallelogram

Area = Width x Height

Trapezoid

$$\text{Area} = \frac{\text{Top Base} + \text{Bottom Base}}{2} \times \text{Height}$$

Circle

2 x Radius = Diameter
Dia. x 3.14 = Circumference
Area = 3.14 x Radius x Radius = 0.785 x Diam. x Diam.

Cylinder

Volume = Area of Base x Height

Cone

$$\text{Volume} = \frac{\text{Area of Base} \times \text{Height}}{3}$$

Prism

Volume = Area of Base x Height

Sphere

$$\text{Vol.} = \frac{4}{3} \times 3.14 \times \text{Rad.} \times \text{Rad.} \times \text{Rad.}$$

Wedge

$$\text{Volnme} = \frac{\text{Area of Base} \times \text{Height}}{2}$$

FIG. 5. AREAS AND VOLUMES.

Job Sheet No. 8

COMPUTE QUANTITIES

Excavation Problems

1. A wash building is 20 by 35 feet outside dimensions. The trench dug for the base of the foundation wall is 12 inches wide, the average depth is 20 inches. How many cubic feet of excavation were there in this trench?

2. A cellar is excavated for this building which is 30 by 60 feet. The excavation is 4 feet 6 inches on the average. How many cubic feet of excavation are there in the cellar? How many cubic yards?

3. Excavation is made for 56 pin footings, the size of the footing is 2 feet square, the average depth of the excavation is 3 feet. How many cubic yards of excavation are there?

4. A building 50 by 75 feet is built on a side hill, the depth of excavation for the basement on the uphill side is 8 feet, on the downhill side is 2 feet. How many cubic yards of excavation are there?

5. A concrete road is to be built 300 feet long. In the first 50 feet there is an average excavation of 6 inches, in the next 100 feet an average excavation of 9 inches, in the following 75 feet an average excavation of 18 inches, and in the last 75 feet, 10 inches. Width 10 feet. The material is loam and light clay mixed. How many cubic yards of excavation are necessary? How many wagon loads must be hauled?

6. A building 20 feet by 35 feet is to be filled with surface soil on which to construct a concrete floor. The average depth of earth fill required is 13 inches. How many cubic feet of earth must be excavated to make this fill?

Compute the volume of the retaining wall shown in Fig. 6, and the quantities of cement, sand and gravel required to construct the wall with a 1–3–6 mix. See Job Sheet No. 30. Use Fuller's rule as given in Vol. I, page 52.

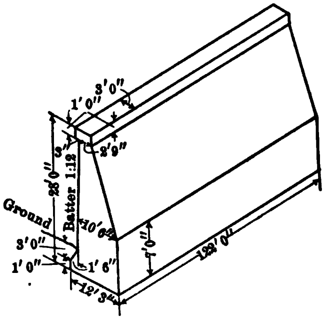


FIG. 6. SECTION OF RETAINING WALL.

NOTE. — Prepare your calculations in a neat form. Submit a rough draft of your form to the instructor for approval before making the final sheet.

Job Sheet No. 9

Vol. I, Chap. II, Pages 8 and 17. Plates I–VII, Page 8

READ DRAWINGS ON LAWLOR BUILDING

Consult plans of Lawlor Building.
Answer the following questions:

1. What is the difference in elevation of the footings of column 1 and column 4?

2. What access is provided from the main floor to the basement and on what sheet is it shown?

3. What kind of wall is provided on the $\genfrac{}{}{0pt}{}{\text{east}}{\text{west}}$ side of the basement and where is this shown?

4. What is the depth of the bottom of the boiler foundation below the paving of the basement?

5. How far below the ground floor is the top of the coal chute? How far above the basement floor?

6. How far above the curb is the terrace level? the ground floor? the top of the coal chute?

7. Why is there a retaining wall provided on the south, and why on the east? Where are the sections of these walls?

8. Why is the line at the outer end of the coal chute, Sheet 1, shown dotted?

9. Why is column 7 provided? Find what it holds up as shown on sheets No. 2 and 5?

10. How is the wall over the coal chute entrance supported?

11. What support have the floors of the office? the vestibule? the workmen's toilet? the entrance from the rolling door? the stairway landing?

12. Which way does the roof slope?

13. What kind of roof? How supported? Which way

do the beams supporting the roof run? How is the skylight supported?

14. Where are the sizes of the roof beams shown?

15. Why is there an oblique line on roof plan Sheet 3?

16. Where are the lengths of the roof columns shown?

17. How does the designer fix the width of the foundation plate?

Referring to specifications:

18. What proportions of concrete are to be used in the following: footings to columns; foundation plate; retaining wall; beams; roof slab; paving?

19. What character of gravel is equivalent to the broken stone?

20. What sizes and quality of sand will be accepted?

21. Is the cement measured loose or as packed in the bag?

22. What part of the building and furnishings will the owner supply?

SECTION II

PRELIMINARY TO CONSTRUCTION — SHEETS 11–17

Job Sheet No. 11

VOL. I, CHAP. XIII, PAGE 329 AND §§188–190

DETERMINE OUTPUT OF LABORERS IN SHOVELING, ETC.

Observe and record the following and compare your observations with information in Vol. I, Chap. XIII, Tables XXVIII to XXX.

1. Using the wheelbarrow, pick, shovel, etc.:
    - (*a*) How many cubic yards of earth can one man pick, load in wheelbarrow, and wheel onto pile in 10 hours, a distance of 20 feet?
    - (*b*) How many cubic yards (same distance) can he wheel of loose sand or gravel from boards or embankment?
    - (*c*) How many cubic yards can he wheel when the wheelbarrow is loaded for him?
    - (*d*) How deep would it be economical to dig and load your own wheelbarrow?
    - (*e*) How many cubic feet should be put on wheelbarrow when wheeling for 10 hours straight?
2. Proper method of loading wheelbarrows:
    - (*a*) How should you load a wheelbarrow wheeling on level boards? On soft earth?
    - (*b*) Up an incline of 30 degrees? On a decline of 30 degrees?
    - (*c*) How would you dump a wheelbarrow, end-ways or side-ways?

Job Sheet No. 12

VOL. I, CHAP. X, PAGE 226

STAKE OUT A TRENCH FOR A FOUNDATION WALL

The outside dimensions of the foundation are 30 by 40 feet, and the wall is 14 inches thick. The trench walls are self-sustaining.

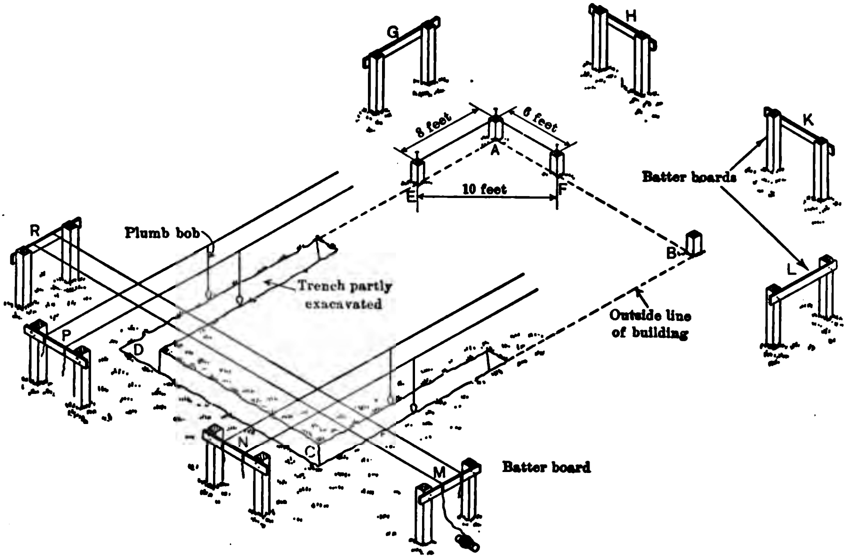


FIG. 7. METHOD OF STAKING OUT EXCAVATION.

1. Why do the dimensions indicated of 6, 8 and 10 feet, make a square corner? See Job Sheet No. 8.
2. Would 12, 16, and 20 feet give a square corner?
3. After the four corner stakes A, B, C, and D have been set, measure the diagonals AC and BD. Are these equal?
4. If they are not equal, are the corners out of square? Repeat the work until satisfactory results are secured.
5. Why is it necessary to place batter boards?

6. What controls the distance between the two lines running between the batter boards? Has the kind of soil and the kind of masonry of the wall anything to do with this? The first stake A has been driven to the height of the top of the foundation wall or an even number of feet below it.

7. Use a carpenter's level and nail the batter board H to the uprights at the level of the top of stake A or an even number of feet above it.

Job Sheet No. 13

Vol. I, Chap. III, Page 26

BRACING A TRENCH

Dig and Brace a Trench in Yielding Soil such as Sand or Gravel

The dimensions of the trench are 4 feet wide and 8 feet deep and 20 feet long. See Fig. 8.

1. Select the tools and organize the gang.

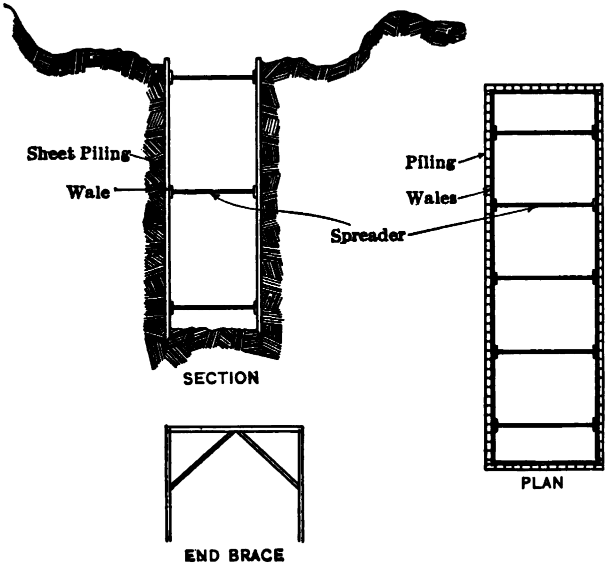


Fig. 8. Method of Bracing a Trench.

2. Prepare bracing materials consisting of sheet piling, wales, and spreaders, following Fig. 1.
3. Estimate the amount of bracing material required.
4. In throwing the material out of the trench, how far should the pile be from the edge?

5. What two difficulties would come about if the earth were thrown at the edge of the trench?

6. Have you left room for the material coming from the bottom of the trench?

7. Will the weight of the pile of excavated material increase too greatly the pressure on the sides of the trench?

8. Which would be better for the sheet piling, the square end or a beveled end?

9. Which way should the bevel face?

10. When the sheet piling bends, insert the wales and spreaders at increasing depths.

11. How far apart should the wales and spreaders be placed, in your judgment? See Fig. 8.

12. How far apart is it necessary to put them satisfactorily to retain the sheet piling?

13. Report the final arrangement of the bracing in the form of a sketch after the work is completed.

14. Estimate the number of man-hours per foot of length for this trench.

Job Sheet No. 14

VOL. I, CHAP. III, PAGE 37. FIG. 17

BUILD A STORAGE HOUSE FOR CEMENT

Sketch a suitable shed for storing two carloads of cement on site, loamy damp soil. Assume 1 carload to contain 900 bags.

1. Should the floor be placed directly on the ground? What is the least clearance space advisable?
2. Should the building be of **waterproof** construction?
3. Why should cement be piled at least 8 inches from the walls of the shed?
4. What is **Warehouse Set** and what causes it?
5. Does cement season in storage?
6. What would happen to cement if it was stored in a damp or wet place?
7. Is lumpy cement fit to use?
8. Can the lumps be powdered? If not how can the cement be made fit for use?
9. Give directions for the proper method of bundling cement sacks.

Job Sheet No. 15

VOL. I, CHAP. III, PAGE 39. FIGS 18, 19

CONSTRUCT A MIXING PLATFORM

1. How large a platform should you have for four men?
2. What size lumber will you use for the platform? For the cleats?
3. How will you keep the cement and water (grout) from running through the platform? Off of the platform?
4. Why will projecting nails interfere with the speed of mixing?
5. What provision would you make for leveling the platform? Sketch?
6. How will you provide easy access of wheelbarrows?
7. Make a bill of materials for the platform.
8. Make a plan and section of the platform and construct it.
9. How many man-hours did it take to build?
10. Report total cost of labor and materials.

Job Sheet No. 16

Vol. I, Chap. III, Page 40. Fig. 20

CONSTRUCT MEASURING BOX AND CALIBRATE TOOLS

(To produce good concrete, economically, quantities of materials used in mixing concrete should be measured, not guessed at.)

On large jobs, where concrete is mixed by machinery and transported in wheelbarrows from stock piles, the use of this box, Vol. I, Fig. 20, causes too much delay. The material is then measured in wheelbarrows or bins. The barrows may be calibrated, that is, the capacity determined. The proper quantity of material is measured into the barrows and the appearance noted. But a better barrow is one with a flat top, holding a definite quantity, from 1½ to 2 cubic feet. A crude method is to determine the number of shovelfuls needed to one bag of cement to make up the mix.

Cement is measured in the bag as packed, and a count of the number of empty bags will check up the use of cement.

1. How many shovelfuls of aggregate to fill up the box?
2. How many shovelfuls of sand and coarse aggregate needed to one bag of cement for a 1–2–4 mix, and for a 1–3–6 mix?
3. How many cubic feet does the wheelbarrow hold? Where is the loading line on the wheelbarrow for a one-bag mix of 1–2–4? 1–3–6 mix?
4. Will **moisture** in the aggregate change the amount of aggregate needed for a batch? How much could this variation be and would it be worth while to take care of it? See Job Sheet No. 29.

Job Sheet No. 17

CONSTRUCT A HOME-MADE TESTING MACHINE FOR TESTING THE STRENGTH OF CONCRETE

Many questions concerning concrete are answered by direct test. The "Training Manual for Concrete," published by the Portland Cement Association, page 19, describes a simple machine which will serve a useful purpose when a testing laboratory is not available.

The testing machine is thus described:

This small, home-made machine was designed by the Muncie (Indiana) Normal Institute for testing specimens either 1 by 1 by 12 inches or 1 by 2 by 12 inches.

It consists of levers so arranged that the load applied to the specimen is increased ten times over that applied to the machine. It is equipped with an automatic cut-off, which prevents the load from increasing after the specimen has failed.

The frame which supports the machine can be made of pine, but the lever arms should be of hard wood. One end of the lower lever supports a can, which is located just below another can containing a supply of dry sand. At the other end of the lever a ball weight is suspended which can be adjusted so as to balance the levers just before the test is applied.

At the center of the bottom of the can containing the sand is a ½-inch hole through which the sand is allowed to flow into the lower box. An automatic cut-off controlled by a coiled spring and trigger is provided. A No. 9 wire is attached to the lower lever and projects through a small opening in the cut-off, when the large hole in cut-off is directly under the opening in the sand supply can. This wire acts as a trigger, and as the beam breaks and the levers descend, the wire is withdrawn from its hole, releas-

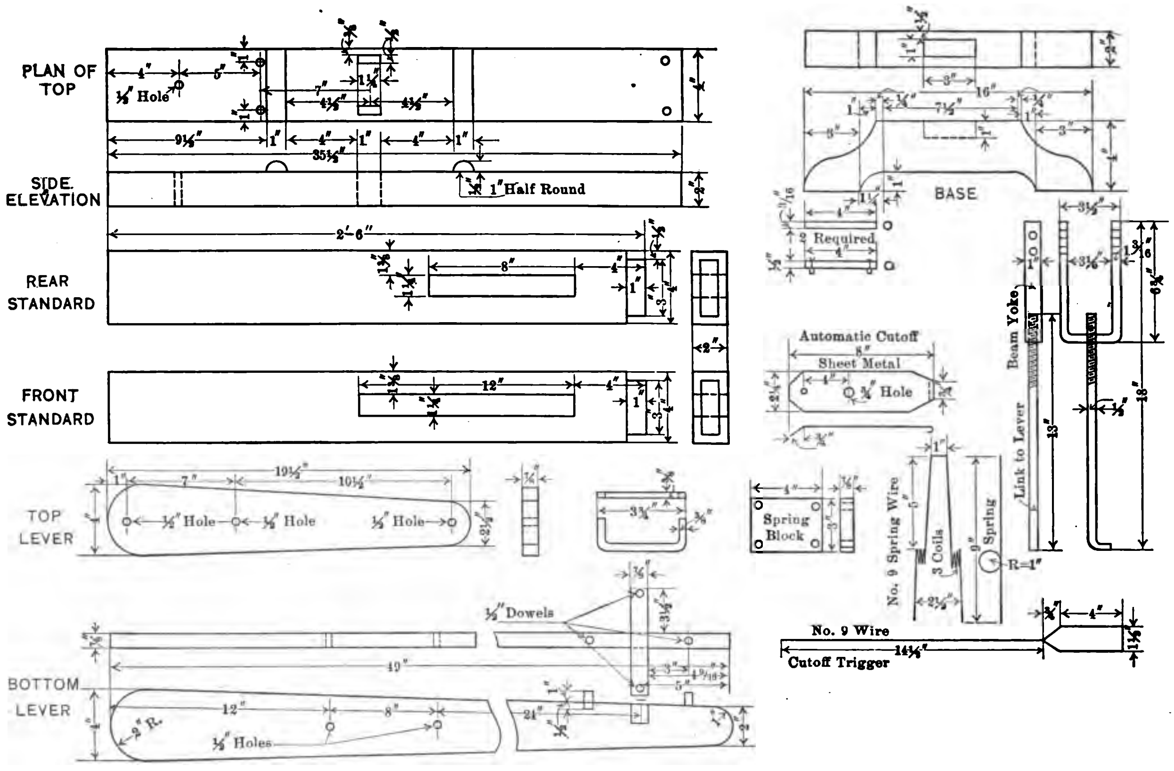


FIG. 9. CONSTRUCTION OF HOME-MADE TESTING MACHINE.

ing the cut-off, which in turn is drawn back by the spring cutting off the supply of sand. The weight of the sand in the lower can is determined and multiplied by ten. This product will give the load which caused the specimen to fail.

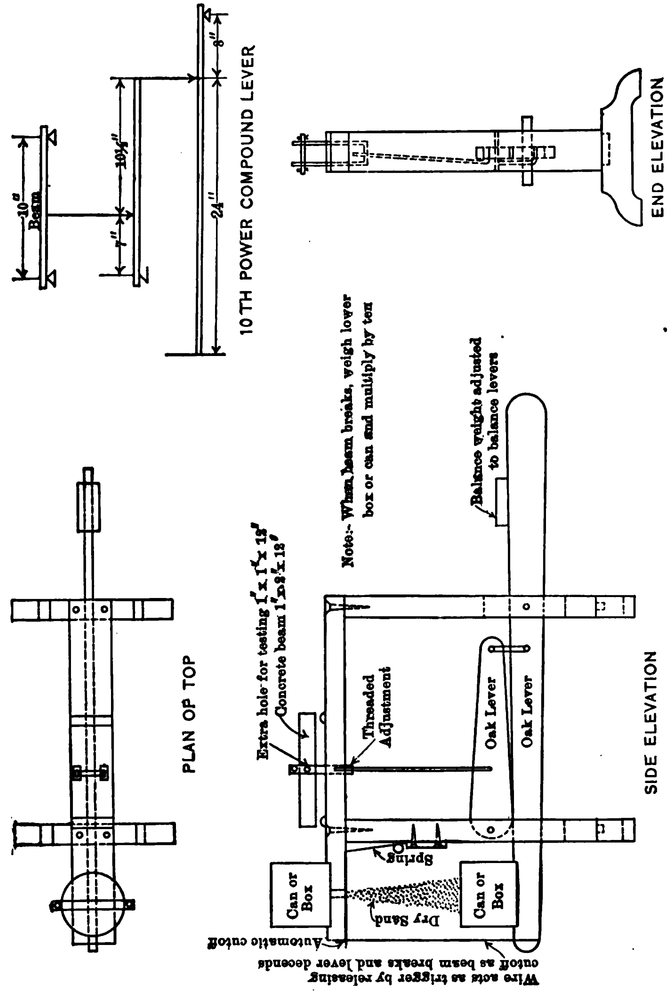

10TH POWER COMPOUND LEVER
10" Beam
10⅝"
7"
24"
8"
END ELEVATION
PLAN OF TOP
SIDE ELEVATION
Note:- When beam breaks, weigh lower box or can and multiply by ten
Balance weight adjusted to balance levers
Extra hole for testing 1"x 1"x 12" Concrete beam 1"x 2"x 12"
Threaded Adjustment
Oak Lever
Oak Lever
Spring
Can or Box
Dry Sand
Can or Box
Automatic cutoff
Wire acts as trigger by releasing cutoff as beam breaks and lever decends

FIG. 10. DETAILS OF HOME-MADE TESTING MACHINE.

SECTION III

INSPECTION, PROPORTIONING AND TESTS OF MATERIALS — SHEETS 20–52

Job Sheet No. 20

VOL. I, PLATE 1. APPENDIX C, PAGE 361

SAMPLE A CARLOAD OF CEMENT

Samples must be taken in a uniform manner if the test results are to be reliable.

Sampling: Obtain a sample by inserting a piece of split tubing through the flap in the bottom of a sack. Each test sample should weigh at least eight pounds. In sampling a car of cement one test sample shall be taken from each 50 bbls. Samples should be placed in heavy paper bags or tight cans and suitably marked and be kept in a dry place.

Samples shall be passed through a sieve having 20 meshes per linear inch, in order to thoroughly mix them, break up lumps, and remove foreign matter.

Job Sheet No. 21

Vol. I. Appendix C, Page 359

TESTING OF CEMENT

Many jobs have failed because of poor cement, which must therefore be tested. **Uniform** methods of making the cement into test pieces must be followed; otherwise different testers will get different results on the same sample.

Test a sample of cement for soundness, time of set, standard practice and strength, and determine if it passes specifications.

Make standard tests as stated in Appendix C, page 359, Vol. I.

Test your understanding of the process by answering the questions. Consult also Taylor and Thompson, Chap. VI.

Consistency of Mix

1. Why should not a less amount of cement be used for a neat pat than 500 grams?

2. Will the amount of water in the sample affect its strength and setting time?

3. Why do different cements require different amounts of water to get the same consistency?

4. How is the standard amount of water determined for each cement? One convenient method is as follows:

Mix a quantity of cement paste and make up from the paste a ball 2 inches in diameter. Drop the ball from a height of 2 feet on a table. The ball should not crack or flatten out more than one-half its original diameter. Vary the percentage of water to meet these requirements.

5. What difficulties would arise from a quick-setting cement?

6. What is a "Flash Set"? If a "Flash Setting" cement has been used, what is the best treatment of the concrete?

7. What construction difficulties arise from a cement that sets too slowly?

Time of Set

8. What are the standard methods used in determining the time of set?

9. What is a normal time of set?

10. Does age hasten the setting time?

There are two distinct stages in the setting of cement: (1) Initial Set and (2) Hard or Final Set.

Observe the appearance of the surface and action under the needle.

11. When the specimen begins to have appreciable strength and hardness is the final set reached?

12. Why will the broken surfaces of the two parts of a broken test piece unite if held together and allowed immersed in water?

Test for Soundness

A cement to be of value must be perfectly **sound**; that is, it must remain constant in volume and not swell, disintegrate, or crumble.

13. What is the size and shape of a neat pat?

14. Why is it advisable to have a thin edge on a pat?

15. Is a pat sound that has a curved bottom surface after passing through the steam test?

16. Do pats that appear sound immediately after passing the test always indicate a sound cement?

Test Pieces for Strength Test

17. Does the amount of water used in making standard mortar briquettes influence their strength?

18. What is the standard sand used for mortar briquettes and what is its size?

19. Why is a thorough mixture necessary?

20. Briquettes usually break in the smallest cross-section. Explain the conditions that would cause them to break in a larger section.

21. What is the area of the smallest cross-section?

22. Would the strength be different if the briquettes were stored in air?

23. What are the usual periods of storage before testing?

24. Should the strength be greater at 28 days than at 7 days?

25. To secure early information about the strength of cement, 1 : 3 briquettes are sometimes tested at 3 days. What strength should they develop?

26. Does the sample of cement pass the specifications of the American Society for Testing Materials?

Consult the above mentioned information in Appendix for specifications.

A 1- by 1- by 12-inch prism of mortar tested as a beam on a 10-inch span affords a good indication of the strength of cement or of sand. This may be loaded very simply with a yoke, scale pan, and weights. Use this prism in test of mortar in the field.

Job Sheet No. 22

VOL. I, CHAP. III, PAGE 45 AND APPENDIX A

TEST A SAND FOR CLEANNESS

Experience has shown that it is necessary to test sand for **cleanness.** Failures of structures have resulted from **impurities** that may not be determined from a general inspection. The old requirement that sand must be sharp has been abandoned.

The foreign matter in the sand may be:

(*a*) Silt and clay. Provided these are **evenly** distributed so that they will not **ball-up** and thus remain in lumps, an amount as large as 10 to 15 per cent of such silt may be allowed in sand. The clay and silt help to fill up the pores in an otherwise porous concrete. Fine limestone screenings also tend to ball-up; and also may prevent the concrete from hardening. The silt is recognized as the fine scum that settles down on the top of the sand when the sand has been shaken in water.

(*b*) This silt may contain **organic** matter, such as loam, sugar, sewage, which may coat the grains of the sand and prevent the cement from adhering, and may even interfere with the hardening of the cement.

Refer to "Concrete Engineers' Handbook," by Hool and Johnson, page 19.

A small amount of dirt or loam may be determined by the eye. A smaller amount by rubbing the sand in the palm of the hand, but a still smaller amount, that may cause a failure, can only be determined by laboratory methods.

Examine a sample of sand.

1. Does the sample appear to be dirty?
2. Do the grains of sand appear to have a coating?
3. Does a dark spot remain in the palm of the hand after the sand has been rubbed?
4. Is there a cracking sound heard when a handful is rubbed near the ear? "Torpedo Sand."
5. Consult "Concrete Engineers' Handbook," page 28, paragraphs 3 and 4.

Determine the amount of silt in the sand by the following tests:

> (*a*) By the method of washing and (*b*) by the method of decantation. (*c*) Fill a 12-ounce prescription bottle to the 4½-ounce mark with the sand to be tested. Stir this up with a wire for thirty seconds, and allow it to stand until the settlement is complete. Measure the relative height of the silt and the sand.

6. What is the per cent of silt by volume in (*c*)?

NOTE. — The per cent of silt by volume is from one to two times the per cent by weight.

7. What is the comparative per cent of silt as determined by the three methods?

Since the silt is likely to contain organic impurities it is **unsafe** to use a sand that has over **three per cent** of silt by weight, without examination by the colorimetric test, or by the strength test of mortar made from sand.

Colorimetric Test: Fill a 12-ounce prescription bottle to the 4½-ounce mark with the sand to be tested, then add a 3-per-cent solution of sodium hydroxide until the bottle is filled to the 7-ounce mark. Allow the mixture to stand over night and then examine the color of the liquid above the sand. Very dark orange is objectionable, a dark brown indicates that the sand is contaminated, while a white or light yellow color indicates that there is little organic impurity present.

8. Report the color of the liquid in the bottle.
9. Does this sand show organic matter?
   (*a*) Are there indications of mica in the sand?
10. Is the sand pure enough to be used for concrete work where strength is required?
11. Examine the following samples of sand and test them by the colorimetric test, and report if these would be accepted or rejected by the test.
    (*a*) A clean washed sand.
    (*b*) A bank sand.
    (*c*) A bank sand containing loam.

Strength Tests of Mortars: The best indication of the satisfactory quality is a sand afforded by testing the **strength** of mortar or concrete made with the sand and a standard Portland cement. (This will not show the defects of limestone dust.)

Make 3 briquettes of 1 : 3 mortar of standard Ottawa sand, using normal consistency.

Make 3 briquettes of 1 : 3 mortar of each of the samples of sand furnished. Make trials with each sand mortar until the consistency feels and appears like the consistency of standard sand mortar.

Cure in standard manner and break all briquettes at 7 days and compare average strengths.

If laboratory is not available test 1 by 1 by 12-inch prisms referred to in Job. No. 17.

RESULTS OF TESTS

Briquettes numbers				
	1	2	3	Average
Name of sand.............				
Ottawa (Standard)........				
Clean washed sand........				
Bank sand................				
Limestone screenings.....				
Sand with loam...........				

The strength of good natural sand mortars ought at least to equal the strength of the standard sand mortars.

(1) Did the briquettes break in the smallest section?

(2) Report which of the sands furnished you for the test are suitable for use in concrete.

12. Would you use the loamy sand after it has been washed for first-class concrete?

Methods of Determining Silt

(1) Silt is determined by washing on the No. 100 sieve for a sample (obtained by quartering) which weighs about 220 grams in its natural moist condition. The sample is dried slowly at temperatures not greatly above ordinary room temperature to avoid baking any clay or similar matter. Two hundred grams of the dry sample is now weighed on the No. 100 sieve, soaked in water for a few moments to soften any lumps, washed under a gentle stream of water, dried under a gas burner, and re-weighed. The per cent of silt is the loss in weight multiplied by 100 and divided by 200.

(The washing test obtains the true silt value because it removes clay which adheres to the grains as a coating which is not separated by sieving in a dry state.)

(2) Determination of silt by decantation is a test for field use only. About 20 c.c. (quartered from a carefully selected sample) is placed in a 100-c.c. graduated glass cylinder with about 30 c.c. of lukewarm water. The mixture is stirred with a wire for 30 seconds, allowed to settle for 30 seconds, and the water decanted into a second 100-c.c. cylinder. The sand left in the first cylinder is stirred up with a fresh portion of water and the process repeated. This is done 4 times. After 1 hour the volume of silt in cylinder No. 2 and the volume of clean sand in cylinder No. 1 is noted and recorded. The per cent of silt is 100 multiplied by the number of cubic centimeters of silt in cylinder No. 2 and divided by the sum of the volumes of silt in cylinder No. 2 and clean sand in cylinder No. 1.

(The method of decantation is better than the method of allowing the silt to settle on top of the sand in one cylinder, but is not as satisfactory as the method of washing.)

(3) **Silt Determination (Road Gravel):** Reference: Paragraph 9, Bulletin No. 555, U. S. Bureau of Public Roads.

A sample of material approximately 50 times the weight of the largest size stone present is used. After thoroughly drying in a hot-air bath, the sample is cooled, weighed, and placed in a pail, covered with water, and thoroughly agitated by means of a steel rod. The water is poured off through a 200-mesh sieve, and the operation of agitation and decantation is repeated until the wash water is approximately clear. The washed material, together with any residue retained on the 200-mesh sieve, is dried to constant weight, cooled and weighed. The loss in weight is expressed as a per cent of the original dry weight of the sample.

Job Sheet No. 23

Vol. I, Chap. IV, Page 72

MEASURING VOIDS IN GRAVEL OR STONE IN THE LABORATORY

The voids or open spaces in aggregates, which should be filled to make a dense concrete, are a **rough measure** of the proportions necessary. The less the voids, the less cement is required.

Find the amount of water required to fill the voids in a measured volume.

A convenient method is as follows: (1) Without tamping fill the measuring box with the sample; (2) Weigh; (3) Pour water into the box until level with the top; (4) Weigh again.

The per cent of voids is

$$\frac{\text{(wt. of water to fill the voids)}}{\text{(wt. of water to fill the measure)}} \times 100.$$

1. Should the measure be level full of material? Why?
2. Will the volume of voids be reduced if the material is shaken in the container?
3. Why is loose measurement usually preferable in case of coarse aggregate?
4. What would be the effect on the volume of voids if the top of measure is not **level** when the water is poured into it?
5. How does **moisture** in the aggregate affect the per cent of voids? See Job Sheet No. 29.
6. Why is this effect greater for sands than for coarse aggregate?
7. Why does a material of uniform size have a larger percentage of voids than one of mixed sizes? Would the actual dimension of the uniformly sized material affect

the voids? Which would have the greater voids, a mass of ½-inch shot or one of 1-inch shot?

8. The most satisfactory measure of voids is by comparison of the weight of the aggregate per cubic foot with the weight of a solid cubic foot of the material. Gravel, for instance, has a specific gravity equivalent to a weight of 165 pounds per cubic foot. Now if a cubic foot of sand weighed, when dry, 110 pounds, the per cent of voids would be

$$\frac{165 - 110}{165} \times 100 = 33\tfrac{1}{3}.$$

For tabulation of results see Vol. I, Chap. IV, page 73, Table VII.

A cubic foot of uniformly-sized shot weighs 355 pounds. A cubic foot of steel weighs 480 pounds. What is the percentage of voids in the shot? Voids in dry sand range from 25 per cent for a coarse well-graded natural sand to 40 or 44 per cent for a very uniform or screened sand.

9. Are void determinations recommended as a basis of proportioning? See Information Sheet No. 40.

Another approximate method which is simplest in apparatus is:

Fill a can with water and pour aggregate in the can, catching the water that flows out. Pour this water back into the empty can, and note the height. The loss represents the voids in the sample. If the height of the can is 10 inches, and the returned water that was displaced stood at a depth of 6 inches, the voids would be 4 inches of height or 40 per cent.

Problem

Dry beach sand and pebbles as submitted for use in a concrete wall show the following results of void tests.

A coffee can 10 inches deep is filled with water. The sand is poured in the can and the water that is displaced by the sand is caught in a pan and then poured back into a can of the same size. This water stands at a depth of 6 inches. What is the per cent of voids in the sand?

A sample of the sand and pebbles, as shoveled into the wagon, is tested in the same way. The poured water stands at a depth of 7½ inches. What is the per cent of voids in the mixed aggregate? What amount of cement should be added to fill the voids?

Note the remarks in Vol. I, page 52, Chap. III, on the inaccuracy of void determinations as a means of proportioning the mix.

See also Job Sheet No. 42.

Job Sheet No. 24

Vol. I, Chap. IV, Page 72

TEST SAMPLES OF SAND AND COARSE AGGREGATE FOR WEIGHT PER CUBIC FOOT

The weight per cubic foot gives a close estimate of the grading and of the amount of voids. See Vol. I, Chap. IV, Table VII, p. 73.

Method of Determining Weight of Aggregate per Cubic Foot

Apparatus: Cubic foot box; an iron rod, ¾ inch diameter and 18 inches long.

1. Fill the box one-third full of the aggregate. Jab or puddle the aggregate with the rod, 25 times; but do not penetrate the layer.
2. Add another one-third and puddle without disturbing the first layer.
3. Fill the box to overflowing, and repeat the puddling. Strike off the surplus and weigh.

Results of Tests

Aggregate	Weight of box and material	Weight of box	Weight per cubic foot in pounds	Weight per cubic yard (dry)	Weight per cubic yard, tons (dry)

Test the following samples both as received and after drying, also when loose and when tamped.

1. Air dry laboratory sand, ¼ inch down.
2. Damp laboratory sand.
3. A commercial washed sand.
4. Standard Ottawa sand.
5. A commercial washed gravel, 1½ inches down to ¼ inch.
6. A bank-run gravel.
7. Crushed limestone screenings.
8. Crushed limestone.
9. Crushed slag.

1. Does the damp sand weigh less than the dry sand? Why?

2. Is the bank gravel heavier than the washed gravel? Why?

3. Does limestone weigh less than washed gravel?

4. If the proportions for concrete are based on **dry** sand, what will be the effect of using **damp** sand on these proportions?

5. If dry sand is bought by the ton and is afterwards used when in a damp condition, in 1–2–4 proportions for concrete, what additional amount would be allowed by weight to make up for the difference between the damp sand and the dry sand? See Information Sheet No. 29.

6. If a cubic foot of crushed limestone and a cubic foot of slag have the same weight, which would have the less voids? See Vol. I, Table LI, p. 436, for weight.*

A well-graded sand which is largely silica or limestone will weigh, when air dry, from 103 to 112 pounds per cubic foot. A well-graded pit-run gravel of the same kind of material will weigh 120 to 130 pounds per cubic foot.

A well-graded limestone or granite with no screenings in it will weigh 85 to 90 pounds per cubic foot.

---

* Slag aggregate weighs from 65 to 80 lbs. per cubic foot.

Tabulate your results and state your opinion of the quality of the aggregates tested.

WEIGHT, POUNDS PER CUBIC FOOT

Aggregate	Loose		Tamped	
	Dry	Wet	Dry	Wet
1.				
2.				
3.				
4.				
Etc.				

Job Sheet No. 25

VOL. I, CHAP. IV, PAGE 67

STUDY SIEVES AND STUDY METHOD OF SIEVING

Sieves are used to study aggregates by separating them into specified sizes.

If **sizes** of sieve **openings** in sieves used by operators are not equal, results of sieving tests will not be comparable and specifications cannot be applied properly.

The size of opening depends upon **spacing** and **diameter** of **wires.** These should be tested for the sieves in use, since the same standards do not prevail in this country.

Sieves are designated by commercial numbers (see Vol. I, page 69), which agree approximately with number of meshes per linear inch. But a No. 20 sieve in one standard may not present the same size opening as another No. 20 sieve.

1. Test the sieve by measuring the number of openings per inch and the diameter of the wire in both directions as a check on the size of openings.
2. Report if sieve is according to specifications.

There are two series of sieves each presenting a different gradation of openings: the Tyler and the A. S. T. M.

I. **Tyler Series.** Each opening double the next lower. These are rapidly becoming standard for tests.

No. or size	Size of clear opening, inches	Diameter of wire, inches
200	0.0029	0.0021
100	0.0058	0.0042
48	0.0116	0.0092
28	0.0230	0.0125
14	0.0460	0.0250
8	0.093	0.0320
4	0.185	0.0650
3/8	0.370	0.0920
3/4	0.740	0.135
1 1/2	1.500	......

II. **The A. S. T. M. Standards.** See *Year Book A. S. T. M., 1916, D–7–16.

No. or size	Size of clear opening, inches	Diameter of wire, inches
100	0.0055	0.0046
80	0.0067	0.0059
50	0.0114	0.0083
40	0.0142	0.0102
30	0.0197	0.0130
20	0.0335	0.0153
10	0.079	0.022

Method of Testing: The aggregate should be dry before sieving.

1. In testing use 100, 250, 500 or 1000 grams of the sample, since the results are then easily turned into per cents.
2. Place the sieves in one nest, the coarsest on top.
3. Place sample to be tested in top sieve.
4. After rough sieving, shake each sieve over a pan to be sure sieving is complete, for a time of from four to ten minutes.
5. Weigh the residues on the sieves and construct table as directed in Job Sheet No. 27.
6. If a Ro-Tap machine is available, repeat mechanically and compare results. See Fig. 32, page 70, Vol. I.

Job Sheet No. 26

CURVE PLOTTING

A study of characteristics of sand and aggregates is best made by **sieve analysis,** and by representation of the results of the sieving in the form of a diagram.

Study the following curves as a preparation for plotting curves of sieve analysis.

1. Figure 11 is a diagram that shows the retail **price** of lumber from **year to year** at rural points in Minnesota.

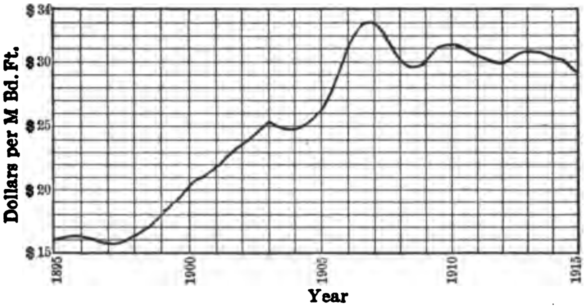


FIG. 11. DIAGRAM SHOWING VARIATION IN PRICE OF LUMBER. The ordinate is dollars per 1000 ft. B.M. and the abscissa is time in years.

This curve shows how the price of lumber has varied with time. The vertical line on the left gives the scale of prices. It is called the **vertical axis,** and any line parallel to the vertical axis is called an **ordinate.** The horizontal line gives the scale of years. It is called the **horizontal axis** and any parallel line is an **abscissa.** The intersection of these axes is called the **origin.**

2. The curve is obtained by plotting a point, whose height is equal to the price of the lumber, on a vertical line which starts from the horizontal axis at the year fixed. The curve then connects these points.

Such diagrams show how one quantity **varies** with another. Further examples are as follows:

3. Figure 12 shows how the **strength of cement** increases with **time** of hardening.

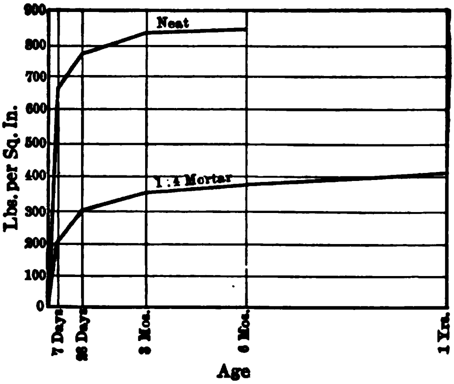


FIG. 12. DIAGRAM SHOWING HOW CEMENT INCREASES IN STRENGTH. **The rate of increase is less as the cement has hardened longer.**

4. Figure 13 shows how **water** affects the compressive **strength** of concrete. Here the vertical axis is the relative strength. The strongest concrete is fixed at 100 per cent. The horizontal axis shows the amount of water. That water which gives the strongest concrete is represented by 100 units. Then the less amount of water for drier and greater for wetter concrete is expressed in comparison with this value of 100 units.

5. Figure 14 shows the **distribution** of particles of various **sizes** in a sample of sand. The horizontal axis gives the **size of the particle** or the **sieve opening**, and the **vertical axis** the **relative amount**, or **per cent**, of this size to be found in the sample. Evidently the curve for fine sand has higher ordinates near the beginning of the curve. A diagram like

this shows graphically the **grading** of the **sand** from fine to coarse and how near it is to the **best grading.** The worker can also tell how much fine or coarse material to add in order to improve the sand. Figure 15 shows an analysis of a bank-run gravel and of a crusher-run stone.

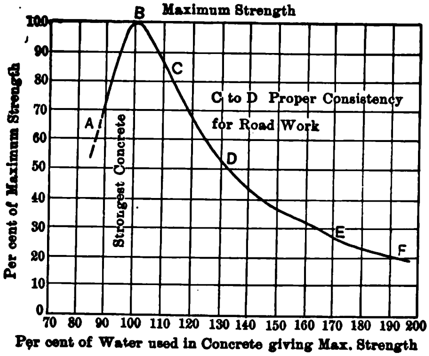


FIG. 13. DIAGRAM SHOWING THAT CONCRETE IS WEAKER BOTH WHEN TOO DRY AND WHEN TOO WET.

The best strength is obtained at the point B. Adding 20 per cent of water to the water at B will lower the strength about 35 per cent. The actual amount of water in gallons per bag is not indicated, because this varies with the kind of aggregate. Notice that both axes show per cents.

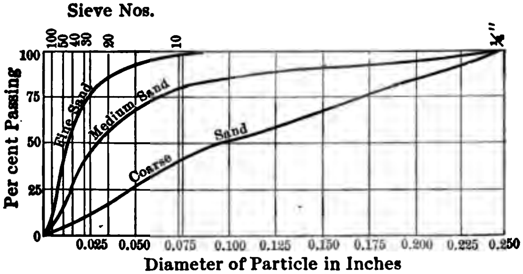


FIG. 14. DIAGRAM SHOWING THE SIZING OF PARTICLES IN A SAMPLE OF AGGREGATE, AS DETERMINED BY A SIEVING TEST.

The student should show on this diagram the curve representing the specifications for sand in Job Sheet No. 28.

6. 42 per cent of sand is recommended for good bank-run gravel. Where will this 42 per cent be plotted as a point in Fig. 15? Not more than 20 per cent of sand is allowed to pass a sieve of 50 meshes per linear inch in specifications for concrete roads. Plot this point on Fig. 14. Plot the percentages specified in Job Sheet No. 28.

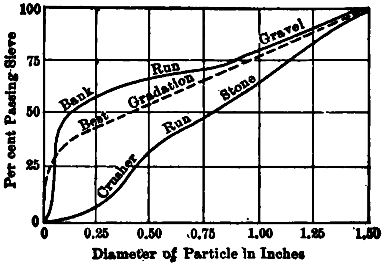


FIG. 15. SIMILAR TO DIAGRAM FIG. 14.

Evidently the gravel has too much fine material, and the crusher run stone too little fine material.

7. Plot diagrams representing the mechanical analysis of the following tests.

TYPICAL MECHANICAL ANALYSES OF SAND AND GRAVEL

A. S. T. M. Standards

Mesh	Per cent retained					
	A	B	C	D	E	
2-inch circular	9	0	....	....	....	....
1½-inch "	14	1	....	....	....	....
1-inch "	21	2	....	....	....	....
¾-inch "	27	5	....	....	....	....
½-inch "	38	15	....	....	....	....
¼-inch "	71	41	0	0	0	
No. 8 square	95	66	36	13	0	
No. 10 "	100	75	41	15	0	....
No. 16 "	....	77	62	27	0	....
No. 20 "	....	80	72	35	0	....
No. 30 "	....	85	86	53	3	....
No. 40 "	....	88	92	68	13	....
No. 50 "	....	89	94	75	24	....
No. 80 "	....	97	98	95	98	....
No. 100 "	....	99	99	99	100	....
No. 200 "	....	100	100	100	100	....

A = Pebbles from the Warsaw Sand and Gravel Co., Winona Lake, Ind.
B = Pit run gravel from the New Haven pit of Allen County near Fort Wayne, Ind.
C = A rather coarse sand from the Million Bros.' pit at Lake Cicott, Ind.
D = A fine sand from the Kickapoo Sand and Gravel Co., Kickapoo, Ind.
E = Fine dune sand from the Pindston Sand Co., Michigan City, Ind.

TYLER STANDARDS SCREENS

Mesh	Per cent retained						
	Pebbles			Mixed sand and pebbles	Sand		
	Coarse	Medium	Fine		Coarse	Medium	Fine
1½-inch square	0	0	0	0	0	0	0
¾-inch "	50	25	9	19	0	0	0
⅜-inch "	86	66	51	49	0	0	0
4 mesh	100	95	86	71	0	0	0
8 "	100	100	100	78	25	10	0
14 "	100	100	100	81	44	24	0
28 "	100	100	100	86	63	46	20
48 "	100	100	100	92	81	70	52
100 "	100	100	100	98	97	91	82

Professor Abrams computes a "**Fineness Modulus**" from tests on the Tyler Screens. He adds together the percentages retained and divides by 100. Thus, for the mixed sand and pebbles,

Fineness Modulus = $\frac{574}{100}$ = 5.74. See Job Sheet No. 46.

A good mixture of sand and pebbles should show a fineness modulus of from 4.5 to 6.

Plot on logarithmic scale.—Instead of a diagram like Figs. 14 and 15 of this sheet, a modified diagram like that of Fig. 16 is convenient. The horizontal distributions are shown on logarithmic scale. The spaces in the diagram between the numbers indicating the Tyler sieves are made equal.

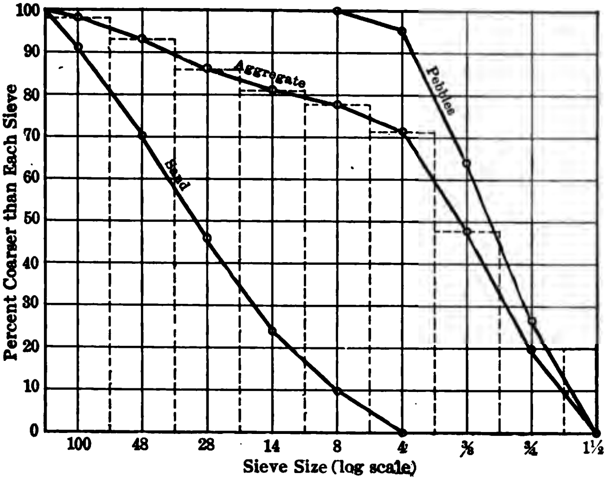


FIG. 16. A DIAGRAM SHOWING SIZING OF PARTICLES ON A LOGARITHMIC SCALE.

The sieves are Tyler standard sieves, in which each opening has an area double that of the next lower number. The ordinates show the per cent retained. This diagram (as well as the Tyler standards) is recommended for general use.

Plot the curve of mixed sand and pebbles; also the curve of medium sand and medium pebbles on a diagram similar to that of Fig. 16.

Job Sheet No. 27

VOL. I, CHAP. IV, PAGE 67

TEST THE GRADATION OF THE SIZE OF PARTICLES IN AGGREGATES

(See Job Sheets Nos. 25 and 26)

A **well-graded** aggregate contains particles of **different** sizes, so that the smaller particles will fill in between the larger particles and so reduce the voids. A more useful indication of quality than the test for voids (Job Sheet No. 23) is the test for **gradation** of particles by sieving.

An inspector also sieves aggregates to find if they are up to specification.

Sieve a 100-gram sample of sand (about 2 pounds), and record the percentage of the sand that is coarser than each sieve in the table below.

RESULTS OF TESTS

Sieve number	Diameter of opening, inches	Amount coarser than sieve	Per cent coarser than sieve
4	0.185		
8	0.093		
14	0.046		
28	0.023		
48	0.0116		
100	0.0050		

Plot these results as in Fig. 14 and also as in Fig. 16, Job Sheet No. 26.

1. Is the sample that you have used a **representative** sample?

2. Have you checked the size of the sieve opening? Is it a **standard** sieve?

3. Dry the sand. Why should it be dry?

4. What is the per cent of fine sand passing the No. 48 sieve?

5. Is the per cent too great for a sand to be used for concrete?

6. Will the sand be suitable for use in the top coat of floor?

Good sands for concrete should, in general, be so graded that the sum of the percentages for the 6 sieves listed above will lie between 270 and 350. Sands and screenings for top coats of floors and sidewalks ought to be so graded that the sum of these percentages will be between 350 and 425.

Use a fifty-pound sample of coarse aggregate, either broken stone or pebbles above the ¼-inch screen. Sieve this through the sieves shown in table below. Record the results and plot them as in Figs. 14 and 16, Job No. 26.

Results of Tests

Size of sieve	Aggregate		
	Amount coarser than sieve	**Amount finer than sieve**	**Per cent coarser than sieve**
No. 4..............			
⅜-inch.............			
¾-inch.............			
1½-inch............			
Sum of percentages			

1. Are there any large stones in the sample?

2. Are the stones clean?

3. What proportion of the stone is soft or porous or laminated?

4. What is the per cent of stone above 1½ inches from the size?

5. Is the sample well-graded from fine to coarse particles?

6. Is the sample tested suitable for concrete?

7. Can you say what proportion of the pebbles is limestone? Quartz?

The best coarse aggregates are made up of particles varying uniformly from fine to coarse grains. For most reinforced work in pavements, foundations, walls, etc., the above range in sizes (No. 4 to 1½ inches) is satisfactory. With this range of desirable sizes the sum of the percentages for the complete range of sieves should be between 650 and 750 in the best aggregates.

Consult specifications for aggregate, page 18, Vol. I, and report if the sample meets the requirements.

Job Sheet No. 28

VOL. I, CHAP. IV, TABLE VI, PAGE 71

SPECIFICATIONS FOR AGGREGATES

Plot the sizings of the following aggregates as in Fig. **16**, Job Sheet 26.

1. American Railway Engineering Association, 1920.

Fine Aggregate (for structures). — The fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry, a screen having holes one-quarter ($\frac{1}{4}$) inch in diameter. Not more than 25 per cent by weight shall pass a No. 50 sieve, and not more than 6 per cent a No. 100 sieve when screened dry, nor more than 10 per cent dry weight shall pass a No. 100 sieve when washed on the sieve with a stream of water. It shall be clean and free from soft particles, mica, lumps of clay, loam, or organic matter.

Coarse Aggregate (for structures). — The coarse aggregate shall consist of gravel or crushed stone, which, unless otherwise specified or called for on the plans, shall, for plain mass concrete, pass a screen having holes two and one-quarter ($2\frac{1}{4}$) inches in diameter, and for reinforced concrete a screen having holes one and one-quarter ($1\frac{1}{4}$) inches in diameter; and be retained on a screen having holes one-fourth ($\frac{1}{4}$) inch in diameter, and shall be graded in size from the smallest to the largest particles. It shall be clean, hard, durable, and free from all deleterious matter; coarse aggregate, containing dust, soft or elongated particles shall not be used.

2. State Highway Commission for Concrete Roads.

86. **Fine Aggregate.** — The fine aggregate shall consist of sand conforming to the following requirements:

The sand shall consist of clean, hard, durable grains. When dry, it shall pass a laboratory screen having circular openings one-quarter (¼) of an inch in diameter. Not more than 50 per cent, by weight, shall pass a No. 30 laboratory sieve, and not more than 10 per cent, by weight, shall pass a No. 100 sieve. It shall be free from organic matter and not more than five (5) per cent, by weight, shall be removed by the washing test.

(*C*) **Gravel.** Gravel shall consist of clean, sound, hard stone, reasonably free from soft, thin, or elongated pieces. Gravel containing clay or coatings of any character shall not be used. It shall show high resistance to abrasion, and no gravel shall be used which, in the opinion of the Engineer, does not show wearing qualities at least equal to crushed stone having a French coefficient of wear of seven (7). Pit run gravel shall not be used. When tested by means of laboratory screens having circular openings, gravel shall meet the following requirements:

		Per cent
Passing 2½-inch screen		100
Passing 2-inch screen	not less than	95
Passing ¾-inch screen	30 to	70
Passing ¼-inch screen	not more than	5

89. If the Engineer deems it advisable, he may permit the use of material that conforms to all the requirements of the specifications for coarse aggregate excepting that of gradation of sizes. He provides however, that sufficient additional cement be used to produce concrete of a quality equal to that resulting from the use of an aggregate of the specified grading.

NOTE. — The old requirement that sand must be "sharp" has disappeared from modern specifications.

Some specifications allow a "tolerance" in gravel aggregate sizings, that is, to permit as much as 15 per cent of the coarse aggregate to pass the No. 4 sieve.

Information Job Sheet No. 29

CHANGES IN VOLUME OF AGGREGATES

Loose and Mixed Volume. — A cubic foot of dry sand and a cubic foot of gravel, that is, **two** cubic feet **separate** volume, will, when mixed together, **shrink** to nearly 1¾ cubic feet of **mixed** aggregate; that is, a mix of 1 : 2 : 4 or 1 : 6 by loose or separate volume is only 1 : 5.2 by combined volume. 100 volumes combine to 86.

Bulking Effect of Water. — When **water** is added to sand it fills the voids and also **wets** the **surface.** The film of water forces apart the particles of the sand. The **mass swells** to a degree depending upon the amount of water and the fineness of the sand. The cement paste also will bulk the aggregate. Pebbles are only slightly affected.

Edwards (Trans. Am. Soc. Testing Mat., 1919, page 494) shows that the maximum swelling or bulking effect in sand occurs with 5 to 6 per cent of water by weight. The amount of bulking in **fine** sand is 30 per cent; **medium** sand, 25 per cent; **coarse** sand, 20 per cent increase in volume. The bulking effect increases with the surface area of the sand. 1 per cent of water may increase the volume 10 to 15 per cent. At 20 per cent of water a **flood stage** is reached and the sand returns to its dry volume.

For example, a coarse sand when dry weighed 107½ pounds, and when wet, with 3 per cent of water, weighed 94 pounds per cubic foot. A common sand when dry weighed 99½ pounds and when wet, with 5 per cent of water, weighed 82 9/10 pounds per cubic foot.

The above values are for sand that has been compacted by tamping. When a sand has been wet in a pile and then shoveled to a loose volume, the bulking may be from ⅓ to ½ more than the values quoted.

Pebbles, being coarse, will hold less water, about 2 per cent by weight, and the bulking is negligible.

Job: Test the amount of moisture and weight per cubic foot in a graded sand that has been out in rainy weather. Find the shrinkage in volume and increase weight of after it has been dried out.

What will be the difference in weight of a carload of 33 cubic yards capacity, when filled with (1) dry sand, and (2) with wet sand as above tested?

Compacting by Ramming. — Broken stone in 6-inch layers may be compacted about 20 per cent by ramming.

Pebbles may be compacted about 11 per cent.

These values are approximately the same for rammed concrete. Dry sand when thoroughly tamped will compact approximately 10 per cent in volume and with 6 per cent moisture about 20 per cent in volume.

Job Sheet No. 30

SEE VOL. I, CHAP. III, PAGE 52

YIELD OF CONCRETE AND QUANTITIES REQUIRED

The **actual volume** of mixed concrete will be the final **result** of the **shrinkage** of the aggregate when mixed and the **bulking** effect of the water and cement discussed in Information Sheet No. 29. For instance, a cubic foot of packed cement with a cubic foot of coarse sand, that, is a 1 : 1 mix, will yield 1.4 cubic feet of compacted plastic mortar. With fine sand the result is 1.51 cubic feet. The same values for the 1 : 4 mix are 3.55 cubic feet and 3.70 cubic feet.

In case of doubt a trial should be made by mixing a batch of the concrete in the proportions required and to the consistency specified. The mixed concrete can then be deposited in a measuring box and the yield determined.

Professor Abrams quotes some test results as follows:

A dry mix of 1 : 5, with a gravel aggregate up to 1½ inch maximum size, yielded concrete of volume 1.05 times that of the mixed aggregate. The wet mix yielded 1.12.

The yield increases as the richness of the mix increases, and also as the size of the aggregate decreases.

Rules for Figuring Quantities.—A simple rule, advanced by W. B. Fuller, is found in Vol. I, Chap. III, page 52.

Approximate amounts of materials required for 1 cubic yard of concrete:

Proportion	Cement, barrels	Sand, cubic yards	Gravel or stone, cubic yards
1 : 2 : 4	1.50	0.45	0.89
1 : 2½ : 5	1.24	0.46	0.92
1 : 3 : 6	1.05	0.47	0.93
1 : 4 : 8	0.81	0.48	0.96

On account of settlement of stone in transit, from 8 to 12 per cent, it is usual to order it by the ton. Weight of broken stone at the crusher is: for limestone, 2300–2600 pounds per cubic yard; for trap, 2400–2700 pounds per cubic yard.

Extensive tables will be found in "Concrete, Plain and Reinforced," by Taylor and Thompson, pages 213 to 217.

Caution: The Aberthaw Construction Company remarks that, on account of waste on the job, the direct use of these tables will result in a shortage of material. The Company estimates the same amount of sand and coarse aggregate for 1 : 2 : 4 concrete as for 1 : 1 : 2, varying only the cement. Thus, for 1 yard of concrete,

Proportion	Cement, barrels	Sand, cubic yards	Stone, tons
1 : 2½ : 5	1.36	0.50	1.30
1 : 2 : 4	1.66	0.50	1.30
1 : 1½ : 3	2.00	0.50	1.30
1 : 1 : 2	2.86	0.50	1.30

1.3 tons of broken limestone is approximately 1 yard.

The usual rule is that the volume of mixed concrete is the total volume of the separate materials, namely cement, sand, and coarse aggregate.

Job Sheet No. 31

Vol. I, Chap. IV, Pages 45 and 46

SAMPLE A GRAVEL PIT AND REPORT UPON ITS QUALITIES AND USE

Equipment: Scoops for collecting sample, set of cloth bags, set of sieves from 2 inches down to No. 50, spring scales, 12-ounce bottle for silt determination, and colorimetric test apparatus.

Consult Bulletin No. 555, U. S. Department of Agriculture, also Taylor & Thompson.

1. Sketch the pit.

2. Has the **loam** and **top soil** been **cleared away** from the top edge of the pit?

3. Has the **top fallen** down into the pit?

4. Are there lumps of **clay** or strata of clay in the pit?

5. Are there any large **boulders** or exposed **ledges** of rock?

6. Is the bank of a homogeneous mixture throughout?

7. Does the bank appear to have a large percentage of fine material?

8. Are there any pockets or layers of material of uniform size?

9. Will one vertical channel from top to bottom of the pit represent the average of the pit?

Sampling

10. Collect a sample by taking a uniformly sized channel of material from top to bottom, placing the material collected in cloth sacks.

11. Make a sketch of location of sample; number the bags to correspond with their origin.

12. Place on a **clean** surface and mix thoroughly, in a

pile, all the bags of this channeled sample. Secure a smaller working sample by "quartering."

"Quartering" is done by spreading the pile in a circle and dividing it into quarters. Two of the opposite quarters are shoveled away and the remainder thoroughly mixed. The operations repeated until the quantity is reduced to the required size. (See Tyler Sieve catalogue for Quartering Machine.)

Testing

13. Take the sample to a laboratory.

14. Examine the sample for cleanness, hardness, size and shape of grain. (See Job Sheet No. 22.)

15. Weigh the sample; sieve on the ¼-inch sieve, and record the percentage passing and retained. (See Job Sheet No. 27.)

16. What percentage is the coarse aggregate of the whole?

17. What percentage is the fine aggregate of the whole?

18. Sieve the coarse aggregate over the sieves, 2-inch down to ¼-inch, and record the percentage retained on the respective sieves. (See Job Sheet No. 27.) Plot results on diagram like that in Job Sheet No. 26.

19. Is the sample of gravel **well graded** from fine to coarse? Will it meet the specifications in Job Sheet No. 28?

20. Sieve the fine aggregate on sieves ¼ inch down to No. 100. Record and plot the results as in (18).

21. What is the percentage of the fine material above the No. 40 sieve in the fine aggregate? Will the sand meet the specification in Information Job Sheet No. 28?

22. Report the proper mix by method of Job Sheet No. 41.

23. Examine a sample of the sand for organic matter and silt. (See Job Sheet No. 22.)

24. Does the sand show a harmful amount of **organic** matter?

25. What is the percentage of silt in sample? (Percentage based on volume.)

26. Is it evenly distributed or in lumps?

27. Would this amount of silt be detrimental to sands for concrete? (Consult Vol. I, pages 349 to 351. See Job Sheet No. 22.)

28. How can the silt be removed?

29. Report what operations would be required for the gravel pit before accepting it as a source of supply of aggregate for concrete roads.

NOTE. — The concrete worker should visit a sand and gravel plant and inspect the methods and machinery for taking the material from the deposit by dredge, pump, or shovel, for washing, and for screening. What is the relation between size of screen and resulting product? What are the various products manufactured, such as ballast, concrete, aggregate, building sand, plasterer's sand, grits, roofing gravel, etc.? Are there appliances for producing "plant-mixed aggregate," that is sand and gravel sent from the screens to the car in specified proportions? In what way would this aggregate save expense to the contractor?

Job Sheet No. 32

VOL. I, CHAP. III, PAGE 53, FIGS. 22–24

MIX A BATCH OF CONCRETE BY HAND

Machine-mixed concrete is **more uniform** than hand-mixed concrete. Small quantities of concrete are not economically mixed by machine, and the arrangement of the work does not always permit the use of a machine. It is important to know the best method of mixing concrete by hand.

Before any important work is started the aggregate should be inspected and other precautions taken as covered in later job sheets.

Careful observation of the concrete in different stages of the mixing will be necessary if this job is to be of most use. The worker will soon learn to know the general **appearance** of **properly mixed concrete** and the reasons for defects. He should know just what **consistency** is required for good workability in various kinds of constructions and how to vary conditions to obtain the right kind of concrete when materials and requirements change. Indeed such intelligence is the aim of these job sheets.

1. See that the mixing board is **level** and **tight** and in a **convenient** place.
2. Place the sand in an even layer on the mixing board and the cement on top of the sand. See that the correct number of wheelbarrows of sand have been supplied.
3. Is the wind blowing the cement away?
4. Two men, facing each other, turn the material over with flat shovels, three times.
5. The mixture should be of a **uniform color** and not streaky.
6. Place the correct amount of coarse aggregate, previously wet, on the cement and sand mixture. Turn the mass over two or three times. Then trough the mass.

7. Add the water in measured pailfuls. The amount of water depends upon the construction. See Job Sheets Nos. 34 and 35. **The workability should be reached with the least amount of water,** which result requires thorough mixing. It will pay to try out a test batch to find the proper amount of water and then to hold to it.

8. Turn the dry materials into the water, allowing no water to get away. Repeat the operation several times until no free water appears. Then turn over several times until the stones are covered with mortar and the mass appears uniform in color and consistency.

9. Are there many stones on the outside of the pile? This would indicate an undue proportion of coarse material.

10. Will mortar appear when the concrete is struck with the shovel?

11. Does the concrete work "smooth" or "harsh"?

12. Harsh working would indicate too much coarse aggregate, or, with bank gravel, too little sand.

13. Will a mix that is apparently too dry become wetter after longer mixing?

Concrete for the base of sidewalks is mixed rather dry, so that prolonged tamping will just bring moisture to the surface, and thus the top may be applied conveniently. Concrete for a foundation plate is wetter, so that, when tamped, the mortar flushes to the surface; the concrete will hold its shape in a pile, and quake like liver when tamped into place. Concrete for walls and beams must flow easily; it will hold a level surface in a barrow, but the coarse aggregate must not sink below the surface. There should be no free water on the surface.

14. Were the mixing board and tools washed clean after the job was completed?

See notes in Vol. I for one-man mixing with hoe (p. 58).

Information Job Sheet No. 33

Vol. I, Chap. IV, Page 75

THEORY OF CONCRETE

The factors controlling the proportioning of cement and aggregates and water to produce concrete are beginning to be understood and their exact influence determined. These influences are described below.

Cement and Water. — The **cement** and the **mixing water** form a paste which cements the particles of the aggregate together. This paste covers the surface of the particles and fills the voids.

This paste also **lubricates** the mass of concrete so that it can be placed in position.

Quality of Paste. — The **quality** of the paste and its amount determine the **strength** of the concrete. The volume of water in relation to the volume of cement, that is, the **water-ratio,** will determine the strength of the paste. (See Job Sheet No. 34 on Amount of Water.) If there is too much water in the paste, it is weak and the resulting concrete is also weak.

Amount of Paste. — The **amount** of water and paste required depends upon the **character of the aggregate.** For the same amount of cement and water, the aggregate which offers the **smallest surface area** and the **smallest per cent of voids** will produce the **strongest concrete.** For instance, a find sand requires more water than a coarse sand for a given consistency and will require more cement for equal strength. Read Job Sheets Nos. 45 and 46, on Surface Area and Fineness Modulus.

Weakening Factors. — The following factors will operate to weaken the concrete: Less cement; increasing the amount of water to increase the mobility; increased surface area; increased voids in the aggregate; dirty aggregate.

Limit of Surface Area. — If the amount of mixing water is too small in relation to the amount of the mixture, it will not be sufficiently smooth or well lubricated. The concrete will be poor.

Definite information upon consistency of concrete and amount of water needed is given in Job Sheets 34 and 35.

Thorough Mixing. — Thorough mixing, up to 1½ minutes in mixer, will increase the workability of the concrete with the use of a less dilute paste, and will therefore add to the strength.

Rule for Consistency. — Use as little water as possible to secure the desired consistency after thorough mixing. The necessary consistency depends upon the character of the job. (See Job Sheet No. 35.)

The various methods of proportioning concrete to meet the principles above stated are covered in Job Sheets 40 to 46.

Job Sheet No. 34

VOL. I, CHAP. IV, PAGE 75

STUDY WATER REQUIRED FOR MIXING

(Read also Job Sheets 33 and 35)

Concrete must be workable on the job. The amount of water to use depends upon several factors:

1. **The Consistency Desired.** — (See Job Sheet No. 35 for amounts of water recommended.)

2. **The Richness of the Mix.** — The more cement, the more water. The cement takes approximately 22 per cent water by weight for gauging. More finely ground cements require more water. (See Job Sheet on Testing Cement, No. 21, Normal Consistency.)

The amount of water is expressed as:

$$\text{The water-cement ratio} = \frac{\text{volume of water}}{\text{volume of cement}}.$$

$$\text{Thus a water-cement ratio of 0.8 is } \frac{\text{0.8 cu. ft. water}}{\text{1 cu. ft. of \textbf{packed} cement}}.$$

This is 6 gallons per bag of cement.

This quantity expresses the quality of the cement paste. The **strength** of concrete **increases** as the **water-cement ratio decreases,** that is, as the paste becomes richer. Fig. 17 shows the relation between water-cement ratio and strength as determined by Abrams.

3. **Size and Grading of Aggregate.** — The water must **wet** the **surface** of the aggregate. Now the total surface area of the aggregates, to be wetted, will depend upon the sizing of the aggregate. **Fine sands** have **more surface** per 100 pounds, or per cubic foot, than coarse sands, and will **require more water.** The amount of water to wet the surface of sand has been measured with conflicting results. Edwards finds 0.38

pound of water required per 100 square feet of surface of aggregate. (See Job Sheet No. 45 for Surface Area of Aggregates.)

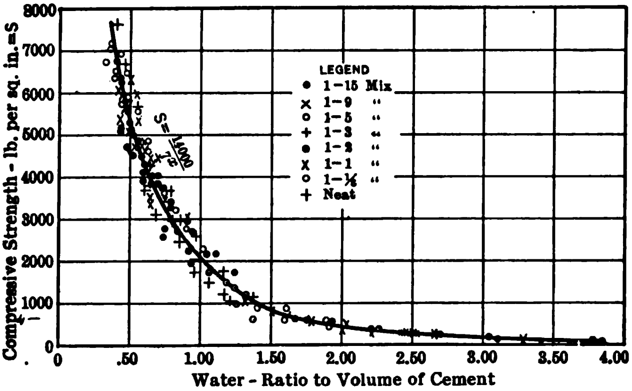


FIG. 17. THE RELATION BETWEEN STRENGTH OF CONCRETE AND WATER RATIO.

(From Bull. No. 1, Structural Materials Laboratory, Lewis Inst., by Professor Duff A. Abrams.)

4. **Absorption of Aggregate.***—Some water will soak into the aggregate. Hard quartz pebbles absorb practically no water; porous sandstone and slag absorb more. Absorption may be assumed to be 2.5 per cent by volume or 1.4 per cent by weight for gravel. This is high for granites and traps.

Job: Test the absorption of a sample of aggregate. Dry, weigh, and immerse the sample. Remove surface moisture with blotting paper.

5. **Water in Aggregate.**—Aggregate will contain moisture. There will be moisture in a gravel bank, and the pile delivered on a job may be wet from rain. The amount of this water can be measured by drying out a sample. This may be 3 to 4 per cent by weight and as much as 6 per cent after a rain.

Job: Test the moisture in a sample of aggregate.

---

* Concrete, one year old, will absorb from 6 to 12 per cent of water by volume when immersed for 24 hours. The specimens in this test are 8 by 8 by 5 inches with worn faces. Mix is 1–4 of gravel aggregate.

Job Sheet No. 35

Vol. I, Chap. IV, Page 75

CONSISTENCY OF CONCRETE

Study the **consistency** of concrete required for different jobs and the **measurement of consistency.**

Consistency refers to the **workability** or mobility of concrete. Concrete which is to be reinforced must flow easily in small spaces and around a mesh of bars; a wet consistency is required. Concrete (which is deposited and tamped) as for the base of a sidewalk will be of a dry consistency. The first will require more water; the second, less water. If each has the same mix, that is, 1 part cement to 5 parts aggregate, the first will be weaker than the second. The rule is to use as little water as possible to produce a workable concrete, because wet concretes are weak.

The **water** and **cement lubricate** the particles of the aggregate to produce workability. Of course, the concrete must be mixed for a sufficient period of time to bring the lubricant into contact with the particles. Concrete appears too dry until it is mixed thoroughly.

Workability requires also that the mix must not separate or be too harsh because of too coarse a mixture.

Note that the same consistency requires differing amounts of water when the materials vary in size. **More water** is required for a **fine aggregate** than for a coarse aggregate. A more easily flowing concrete is obtained by adding cement. The **cement** may be **increased** and the **water-cement ratio diminished** without changing the consistency; but then the **strength increases.**

Young (Engineering News-Record, Jan. 1, 1920) shows the effect of adding cement and lowering the water-ratio, keeping the consistency the same. Thus

Pounds of cement per 100 square feet of surface of aggregate	1	2	3	4	5
Water-ratio	1.358	0.838	0.658	0.571	0.518
Compressive strength	1074	2770	3900	4605	5100

The mixes 1 and 2 are harsh; 3 to 5 are normal. This table illustrates the function of the cement in lubricating the mix.

Measurement of Consistency. — Judging consistency by eye is a good guide for an experienced man. But a more definite measure is needed to control large jobs. Otherwise a contractor may sacrifice the quality of the concrete in order to save labor in placing it.

1. **The Slump Test.** — Figures 18 and 19 show the apparatus and results of the slump tests devised by Abrams.

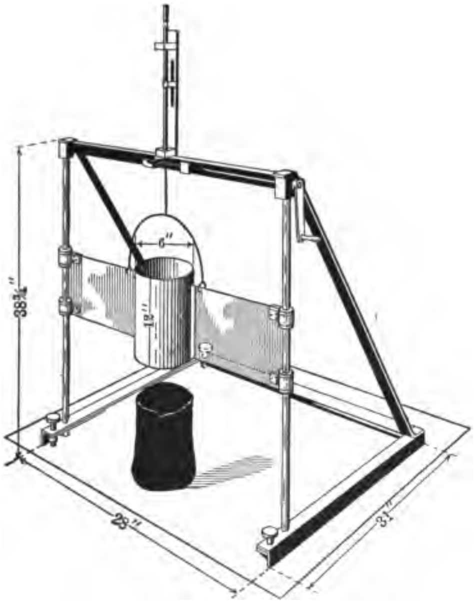


FIG. 18. APPARATUS FOR MAKING SLUMP TEST.

2. **Description of Slump Test.** — (*a*) Mix the concrete thoroughly, adding the estimated amount of water.

(*b*) Tamp the concrete into a galvanized iron mold which is a cylinder 6 inches in diameter and 12 inches high. The cylinder is filled in two layers. Each layer is tamped for 40 strokes with a $\frac{5}{8}$-inch round steel rod.

(*c*) Then draw the mold up, off of the specimen, and note how much the specimen shortens or slumps in height. The consistency is expressed by the slump. Consistency = 1.0, slump is $\frac{1}{2}$ to 1 inch. Consistency = 1.10, slump is 5 to 6 inches. Consistency = 1.25, slump is 8 to 10 inches.

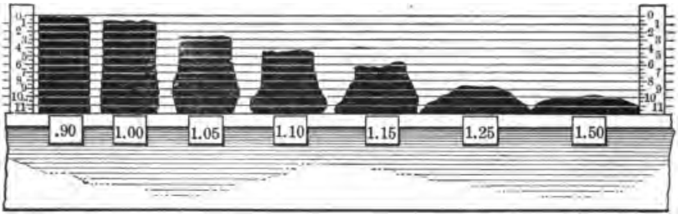


FIG. 19. APPEARANCE OF CONCRETE IN SLUMP TEST.

This test applies to sands and gravels better than to sand and broken stone. It is more reliable for wet mixes.

Professor Abrams shows the following relation between consistency and strength for a 1 : 5 mix. (Compressive strength at 28 days.)

Relative consistency....	0.9	1.0	1.2	1.4	1.6	1.8	2.0
Strength..............	2300	3000	2200	1500	1200	1000	900

Evidently the more easily flowing concretes are the weakest.

Job: Mix aggregate and cement with water to a consistency of 1.0, 1.10 and 1.25. Report the ratio of volume of water to volume of cement, that is the water-cement ratio.

NOTE. — Some difficulty is experienced because of the concrete sticking to the cylinder. The cone test is recommended to avoid this.

2. **Cone Test for Consistency.** — In place of the cylinder a truncated cone is used, 8 inches diameter of base, 4 inches diameter of top and 12 inches high. The corresponding slumps are about $\frac{3}{4}$ as great as from the cylinder test.

3. Bureau of Standards Jigging Table Tests for Consistency.—A measured mass of concrete is jolted so as to spread outward on a table. For instance, a concrete of the consistency for concrete road work will spread 1.8 times the original diameter; for reinforced concrete, 2.0 times the original diameter. See Engineering News Record, May 27, 1920.

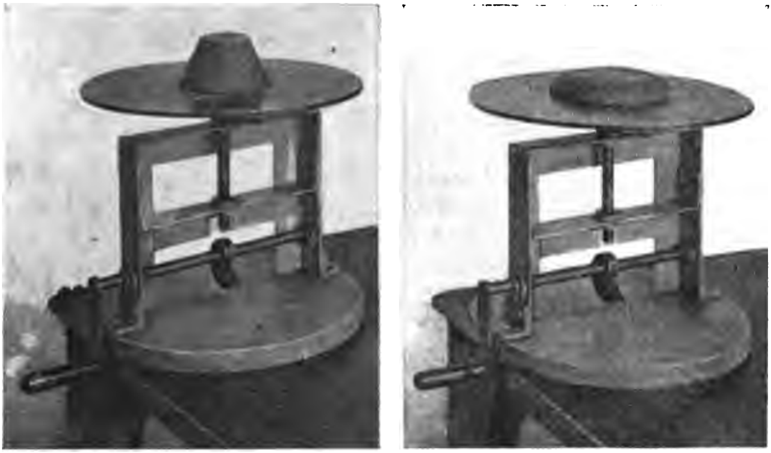


Fig. 20.

Flow Table for Measuring Consistency of Concrete as Developed by G. M. Williams, *U.S. Bureau of Standards.*

Result of Action of Flow Table.

Specifications for Construction of Concrete Road.—(Extracts from the Standard Specifications and Contract of the Indiana State Highway Commission of 1919.)

"**Consistency.** The consistency of the concrete shall be such that, when a cylinder six inches in diameter and twelve inches in length is filled with concrete and tamped until all voids are filled and a slight film of mortar appears on the surface, and the cylinder is then removed, the vertical settlement, or 'slump,' of the concrete shall not exceed two inches when a mechanical finishing machine is used, nor more than four inches when the finishing is done by other methods permitted in these specifications."

The following rules will be a guide.

RULES FOR USUAL CASES OF USUAL AGGREGATES

Mix	Kind of work	Gallons of water per bag of cement	Slump test, inches	Relative consistency
1-2-3	Tamped concrete.....	5½-6	½- 1	1.0
1-2-3	Concrete road........	6 -6½	5 - 6	1.10
1-2-3	Reinforced concrete..	6½-7½	8 -10	1.25
1-2-4	Tamped concrete.....	6 -6½	½- 1	1.0
1-2-4	Concrete road........	6½-7	5 - 6	1.10
1-2-4	Reinforced concrete..	7½-8	8 -10	1.25

The worker will generally determine by trial the amount of water needed, on the basis of the above table, and use this measured quantity afterward.

In **mixing** concrete we use the smallest amount of water that will give a workable mix. In **curing** concrete we use as much water as is possible.

Caution: If wet mixes with much fine material, are churned when deposited in deep forms, a scum will rise to the surface. This scum, of laitance and silt, will not harden. (See Vol. I, page 108.)

Job Sheet No. 36

Vol. I, Chap. IV, Page 65

STRENGTH OF CONCRETE OF VARIOUS PROPORTIONS

(When laboratory is available)

Out of the same aggregate as used in Job Sheet No. 32 make test pieces of concrete mixed in 1–2–4, 1–2½–5, and 1–3–6 proportions, and report the relative strength of these by actual test. The test pieces are cylinders 6 or 8 inches in diameter and 12 or 16 inches high. The aggregates are sand and pebbles selected to meet the first specifications in Job Sheet No. 28.

1. Sieve the aggregate and determine the Fineness Modulus. (See Study Sheet No. 46.)
2. The consistency should be such that the sag under the Abrams test will be from 5 to 6 inches.
3. Make three cylinders of each proportion.

Make three additional cylinders mixed in the proportion of 1 part cement and 6 parts combined aggregate.

4. Report the water-cement ratio.
5. Puddle the concrete into the molds in 6-inch layers. Strike and trowel off the top evenly. Mark each cylinder.
6. Determine the volume of the mixed concrete in percentages of the separate volumes of the cement and aggregates.
7. Before testing, weigh the cylinders.
8. Test these after they have hardened for 14 days under damp sand.
9. Bed the cylinders evenly in the testing machine with plaster of Paris, and be sure that the axis of the cylinder is in the axis of the testing machine. Why are these precautions necessary?
10. Apply the load slowly and record the maximum load carried by each cylinder. Sketch the failure.

11. Record the results in the table below.

Cylinder number	Weight	Mix	Strength, pounds	Strength, pounds per square inch
		1-2-4 1-2-4 1-2-4		
Average				
		1-2½-5 1-2½-5 1-2½-5		
Average				
		1-3-6 1-3-6 1-3-6		
Average				
		1-6 1-6 1-6		
Average				

12. Does the strength increase directly as the percentage of the cement in the cylinder?

Note.—A convenient, economical, and satisfactory mold for test pieces is a commercial water-proofed cardboard container 6 inches in diameter and 12 inches high. These are, of course, only used once. They cost about 8 cents each.

Job Sheet No. 37

VOL. I, CHAP. VII, PAGE 171

PROPORTIONS OF MATERIALS IN CONCRETE

Consult Table XIX, Volume 1, page 171.

1. Note that these proportions are by volume 1–2–4, for instance, 1 part packed cement, 2 parts fine aggregate, 4 parts coarse aggregate. The aggregates are measured separately, and then recombined.

2. What would be the proportions of gravel concrete if the sand and pebbles were used in combined volume? If a gravel deposit were available in which sand and pebbles were in the correct proportion, and clean, what operations would be avoided by its use as found? How many parts cement to parts combined aggregate would you specify for a water tank? (See Job Sheet No. 29.)

3. How many cubic feet of loose cement are equivalent to one cubic foot of packed cement? What would be the equivalent of 1–2–4 if the cement were measured loose?

4. Which jobs require a tight concrete and which a strong concrete? How is each secured?

5. What is the leanest concrete that could be successfully mixed and placed, as, for instance, when merely a protection against rats is desired?

6. Which requires the greater labor cost in mixing and placing, a lean mix or a rich mix? — also a dry or a wet concrete?

7. Will an arbitrary proportion, as 1–2–4, suit equally well two aggregates that differ in the sizing of the sand? How can the proportions be changed to suit the character of the aggregate in order to secure the desired strength with a saving of cement? (See Job Sheets Nos. 40 to 46.)

8. If early strength is desired, as, for instance, in a foundation for a city pavement, what proportions should be specified?

Job Sheet No. 38

VOL. I, CHAP. IV, PAGE 75

DEMONSTRATE THE RELATIVE STRENGTH OF CONCRETE OF DIFFERENT CONSISTENCIES IN 1 : 2 : 4 MIXTURE

(Provided laboratory is available)

The **amount of water** used in mixing concrete may be as **important as** the **amount of cement.** The less the water the stronger the concrete. Different amounts of water are required for different jobs. Use as little as will give the consistency required for the particular job.

1. Mix nine cylinders in sets A, B, and C of three each, 6 or 8 inches in diameter, and 12 or 16 inches high of 1:2:4 concrete, in sets of three each. Materials to be a well graded mix of sand and pebbles. Calculate the amount of cement, sand, and pebbles, or stone needed.

2. In set "A" use enough water to produce a consistency of 1.0 requiring from 6 to 6½ gallons per bag of cement. If the aggregate is damp make an allowance for this. Mix this very thoroughly and tamp it thoroughly into the molds. What is the water-cement ratio? (See Job Sheet No. 34.)

Will this concrete quake like liver when tamped? Will water come to the surface when smoothed with trowel or struck with shovel? Will water appear after thorough tamping? Will this concrete hold its shape in a pile?

Find the sag, using the Abrams test. (See Job Sheet No. 35.)

3. Mix set "B" to a consistency of 1.10, requiring from 6½ to 7 gallons of water per bag of cement, and puddle in molds. What is the water-cement ratio and sag under Abrams' test? Describe the appearance and action of this concrete.

4. Mix set "C" to a consistency of 1.25, requiring from 7½ to 8 gallons of water per bag of cement, and fill the molds, jarring the latter to settle the concrete.

How does this concrete act when piled? Will it assume a level surface in a vessel? Will the pebbles or stone sink below the surface or be kept floating? What is the sag under the Abrams' test?

5. Cure the cylinders under damp sand.

6. After 14 days weigh the cylinders and test them for compressive strength in the laboratory and compare the average strength and weight of the three sets, A, B, and C.

Which degree of consistency produces the strongest and heaviest concrete?

For what kind of structure would the consistency of each set be fitted?

7. Report if the strength varies with the water-cement ratio. (See Job Sheet No. 34.)

Job Sheet No. 39

Vol. I, Chap. IV, Page 73

DEMONSTRATE THE RELATIVE STRENGTHS OF MORTAR MADE FROM FINE AND COARSE SANDS WHEN MIXED 1:2 AND 1:3

(Provided a laboratory is available. If not, use the home-made testing machine)

Coarse sands make **stronger** concrete **than fine sands.** The latter require more water for the same consistency. However, some fine sand may be necessary for a workable mix.

1. Select samples of sand A, B, C, and D as follows:

A — All passes No. 30 sieve,
B — All passes No. 8 sieve,
C — All passes No. 4 sieve,
D — Standard Ottawa Sand.

2. Determine the per cent of voids and the weight per cubic foot of the sands. (See Job Sheets 23 and 24.)

3. Mix up a plastic mortar and make five 2 by 2-inch cubes of each sand, or 1- by 10-inch prisms, in 1 : 2 and also in 1 : 3 mix.

4. Have you secured the same consistency in each mixture?

5. Which sand requires the greatest amount of water? Report the water-cement ratio.

6. Mix each batch with equal thoroughness and tamp in molds equally well.

7. Store these specimens in moist sand and test them for comparison after they have hardened 14 days.

8. Weigh and test the specimens.

9. Are the specimens evenly bedded and in the axis of the testing machine?

10. Operate the testing machine slowly and determine the maximum load supported by each specimen.

11. Tabulate the results and report your conclusions.

12. Which sand produces the strongest mortar in the 1 : 2 and in the 1 : 3 mix?

13. Do the loads increase as the weights of the specimens increase?

14. Do the loads increase as the percentage of cement increases?

15. Do the loads increase as the voids in the sand diminish?

16. Do the loads increase as the water-cement ratio decreases?

17. Will there be more surface to be coated with the cement in a fine than in a coarse sand?

18. Will it be easier to fill the voids in a coarse than in a fine sand?

19. Would a mixture of these sands be better than one sand alone? How should you determine the best proportions in which to mix them?

Consult Taylor & Thompson and report if your results agree with the text.

For use in home-made testing machine, (See **Job No. 17**), make 1 by 1 by 12-inch prisms.

Information Sheet No. 40

Vol. I, Chap. IV, Page 74

THE PROPORTIONING OF CONCRETE MIXES

The job and information sheets which follow disclose the fundamental principles that govern the amounts of cement and aggregates to produce a concrete for a particular construction.

The concrete worker is not likely to have to design and control concrete mixes for large jobs involving thousands of yards of concrete. Nevertheless, he can make the best use of the materials that are available to him on small jobs by understanding these principles. A proportion of 1 : 2 : 4 means 1 part of packed cement by volume, 2 parts fine aggregate, and 4 parts coarse aggregate by volume.

1. **Proportioning by Arbitrary Mixes.** — (See Vol. I, Chap. VII, Table XIX, page 171.) (See Job Sheet No. 37.)

The engineer studies the materials he expects to use and fixes the proportions, as 1–2–3, 1–1½–3, 1–2–4, to suit the material and the kind of job. Specifications are written for the aggregate, which is tested as received, and mixed as specified.

This proportioning is approximate and may be wasteful in large jobs, when the aggregate used is not like that intended by the designer.

Job: Perform Job Sheet No. 43, Proportioning by Arbitrary Mix.

2. **Proportioning by Void Measurement.** — The arbitrary mixes were fixed on the idea that the voids in the coarse aggregate were 50 per cent, and would be filled by sand to the amount of ½ the coarse aggregate. Thus — 1 : 2 : 4 or 1 : 3 : 6. The mortar was made 1 : 2 or 1 : 3, as a stronger or weaker concrete was needed.

Often the proportions are fixed upon the basis of the voids which are found in the aggregate by actual measurement. The method is unreliable because (1) the voids are not measured accurately, and (2) because the cement paste must not only fill the voids but coat the surfaces of the particles.

However, this method is useful at times.

Job: Perform Job Sheet No. 42.

3. **Proportioning Gravel Aggregate by Method of Iowa Highway Commission.** — Gravel pits often contain an excess of sand and a deficiency of pebbles, so that a 1–2–4 mix is wasteful of material. The Iowa method, as worked out by Testing Engineer Crum of the Iowa Highway Commission, is to increase the cement when the sand increases. This method may also be used to modify proportions when the aggregates change in sizing.

Study the Job Sheet, No. 44, on Crum's Method. See Vol. I, page 50.

4. **Proportioning by Surface Area.** — Since sands and coarse aggregate vary in sizing, and so offer variations of surface area and voids, constructors endeavor to suit the mix, that is, the proportions, to the sizing of the aggregate. In mixing together different sands and coarse aggregates, the best mix is claimed by some to be that which reduces the surface area to a minimum.

Study the Job Sheet, No. 45, on Surface Area.

5. **Proportioning by Fineness Modulus.** — The researches of Professor Abrams lead him to the conclusion that the best index of the concrete, making value of aggregates is the Fineness Modulus.

Study the Job Sheet, No. 46, on Fineness Modulus.

6. **Proportioning to fit an Ideal Curve.** — It is assumed that the gradation of the sizes of the aggregate should follow a regular law. The aggregate is sieved, and the proper amounts of the various sizes calculated in accordance with this law. These amounts are recombined. Read Vol. I, page 351.

Recommendations. — The concrete worker will find the method of **arbitrary mixes** of materials as fixed in specifications **a safe procedure.**

When the **fine aggregate** is in **excess** and the sizing or weight per cubic foot varies, the **Iowa method** is safe and simple. The methods (4) and (5) are under examination by engineers, and their value will be better determined after experience and further research.

Information Job Sheet No. 41

VOL. I, CHAP. III, PAGE 47. FIG. 21

PROPORTIONING OF GRAVEL CONCRETE

A simple method is used by the Iowa State Highway Commission for proportioning concrete when **gravel varies in sand content.** The **ratio of cement** to total aggregate is **increased** directly as the per cent of sand increases. The weight of the aggregate enters into the result. If the amount of cement were not increased as the sand increases the mortar would be lean.

It is not recommended that pit-run gravel be used as received without examination, because the material is too variable and the proportions would have to be changed too often. But when there is less or more sand, we can adjust the mix. If there is not enough coarse material for a 1 : 2 : 4 mix we can add more cement. In this way the supply of our building materials may be conserved. The procedure is as follows:

1. Find the loose weight of the gravel per cubic foot, shaken into box, not tamped.
2. Sieve the sample over the ¼-inch sieve and determine the per cent of sand.
3. Consult the charts, Fig. 21 and Table on page 50, Vol. I, and find the correct mix.

There are three standard classes of concrete, all with 42 per cent of sand, recommended by the Iowa Commission.

Class I. — Proportion 1 : 4½, strength 2400 to 3000 pounds per square inch, suitable for reinforced concrete, water-tight concrete, and base course of concrete pavement.

Class II. — Proportion 1 : 5½, strength 1800–2400 pounds per square inch, suitable for first-class foundations, gravity section piers and abutments, and base course of non-reinforced floors and walks.

Class III. — Proportion 1 : 7, strength 1200–1800, suitable for large foundations and heavy mass work in general.

Example 41a. The gravel from a pit contains 60 per cent of sand instead of 42 per cent. What should be the mix for Class I concrete? The gravel weighs 110 pounds per cubic foot. Consult Fig. 21, Vol. I, run up vertically from 60 per cent and out horizontally from 110. The two lines meet at a proportion of 1 : 4.

Example 41b. The gravel contains 75 per cent of sand and weighs 107 pounds per cubic foot. By the diagram the proportion should be 1 : 3.3 or 1 bag of cement to 3.3 cubic feet of mixed sand and pebbles as delivered from the pit.

Of course the gravel should be clean. If we were to keep the proportion 1 : 4½ with this 75 per cent of sand the concrete would be in Class II.

Tests on a series of concretes proportioned by this method show as follows (see Job Sheets 45 and 46): Class II concrete, consistency constant. Sand 103.6 pounds per cubic foot. Pebbles 103.5 pounds per cubic foot, 1½-inch down.

Per cent of sand	33	42	55	65	75	85	95
Weight per cu. ft. (100 lbs.) mixed aggregate	114	115	117	116	113	109	107
Fineness modulus	5.33	5.01	4.58	4.24	3.92	3.60	3.27
Surface area, sq. ft. per 100 lbs.	800	1000	1200	1400	1500	1750	1950
Per cent water	10.1	9.6	10.2	10.3	10.6	11.7	12.4
Proportion (loose vd.)	1.6	5.5	5.0	4.50	4.25	4.0	3.75
Strength (28 days)	1343	1920	1800	1255	2135	2005	1860

The extra cement will increase the cost of the concrete. The aggregate will, however, probably be cheaper if all of the sand of the pit can be used. A computation will show if the total cost will be less.

Job Sheet No. 42

Vol. I, Chap. IV, Page 72

PROPORTIONING BY VOID MEASUREMENT

Measure the void spaces in a sample of sand and pebbles and calculate the proportionate amounts of cement, sand, and gravel to make a dense concrete, and report comparison of results with standard arbitrary proportions.

Materials: ½ cubic yard of good pit gravel (mixed sand and pebbles) suitable for concrete.

Equipment: Set of sieves, weighing apparatus and box holding one cubic foot.

Instruction: By method of quartering (see Job Sheet No. 31), divide the sample into 4 parts, one cubic foot in each, and mark them A, B, C, and D. Separate the sample A into 2 parts. (1) passing through the ¼-inch sieve, and (2) retained on the ¼-inch sieve.

Examination of Aggregate

It is arbitrarily agreed that the material passing through the ¼-inch sieve will be considered as sand or fine aggregate and that retained on the ¼-inch sieve as pebbles or coarse aggregate.

1. Dry, and then sieve Sample A through the ¼-inch sieve.
2. Check the openings in the sieve (see Job Sheet 25).
3. Weigh the amounts of sand and pebbles. Find the volume of each when shaken into the cubic foot box.
4. Compute the percentage of sand in Sample A, (1) by weight and (2) by volume.
5. How much is the sum of the separate volumes of the sand and pebbles greater than the volume of Sample A? Explain the result. (See Job Sheet No. 30.)

6. Is the proportion of fine to coarse material in the sample correct for good concrete? (See Job Sheet 28.)

A solid cubic foot of the rock from which the gravel was produced weighed nearly 165 pounds. (See Job Sheet No. 23.)

7. Calculate the void spaces in the sand and gravel by comparing the weight in the above statement with the weight of the sand and pebbles per cubic foot. Call these "absolute voids." (See Job Sheet No. 23.) (See Vol. I. Chap. IV, Table VII, page 73.)

8. Compute a volume of water equal to the volume of the voids in the sand, also in the pebbles, and report if these amounts of water can be poured into the sand and pebbles of Sample A. If not, why not? (See Job Sheet No. 23.)

9. Determine the void spaces on the basis of water determination. (See Job Sheet No. 23.)

10. Report the per cent of voids as computed in (7) and measured in (9).

Mixing Cement and Aggregates by Voids

1. Assume that a bag of cement weighs 94 pounds and is a cubic foot. Calculate the volume and weight of cement that would fill the voids in the sand in Sample A as determined in (7), and state the proportions of cement and sand, (*a*) by weight and (*b*) by volume.

2. Weigh out this amount (*a*) of cement in (1) and mix it with water and sand to form a plastic mortar. Place this in the measuring box and determine how much the volume of mortar exceeds the volume of sand. Why the excess? Consult Taylor & Thompson's "Concrete, Plain and Reinforced," and report if your results agree.

3. Compute the volume of mortar, of proportions as found in (2), necessary to fill the voids in the pebbles. Mix this with the moistened pebbles to form a plastic concrete (see Job Sheet No. 32) and report how much the volume of the resulting concrete (tamped in the measuring box) is

greater than the volume of the pebbles. Compare with text as in (2). Does the mix appear harsh, with pebbles in excess, or does it work smoothly? What per cent of water was used in relation to cement? How many gallons per bag?

4. Why is there an increase of volume?
5. What is the weight of the concrete per cubic foot?
6. State the proportion of the concrete as determined, thus

1 cement — sand — pebbles by loose volume.
1 cement — combined aggregate by volume.

Job Sheet No. 43

VOL. I, CHAP. VI, PAGE 65

PROPORTIONING BY ARBITRARY MIX

(Refer to Job Sheet No. 42)

1. Separate sample B into sand and pebbles. Mix a batch of concrete, composed of ¼ bag cement, ½ cubic foot of sand, and 1 cubic foot of pebbles, to a relative consistency of 1.10 (see Job Sheet No. 35) requiring about 6 to 6½ gallons of water per bag. Measure and record slump.

What volume of water in relation to volume of cement was used?

How many gallons per bag?

What are the proportions of the concrete?

What is its weight per cubic foot?

Job Sheet No. 44

PROPORTIONING CEMENT AND BANK RUN GRAVEL

(See Job Sheet No. 42)

Mix cement with Sample C in the proportion of 1 : 6 of combined aggregate (as received) to a consistency of 1.10, and determine the weight per cubic foot of the resulting concrete when puddled in the measuring box. Report the water-cement ratio.

1. Which of the three concretes in Jobs Nos. 42, 43, and 44 is the densest?
2. If the sand in the gravel had been all fine sand, would the concrete have been as dense?
3. If there had been only a small proportion of pebbles in the gravel, would the concrete have been as dense?
4. What would the mix be under the Iowa method? (See Job Sheet No. 41.)

Bank gravel is generally deficient in coarse material and may contain twice as much sand as pebbles, whereas the mix called for has twice as much pebbles as sand, the latter being the material below $\frac{1}{4}$ inch.

The statement has been made that 1 bag of cement, 2 cubic feet of sand, and 4 cubic feet of pebbles will produce only $4\frac{1}{2}$ cubic feet of concrete, whereas 1 bag of cement and 6 cubic feet of bank gravel will produce about six cubic feet of concrete. Therefore, the 6 cubic feet of concrete with 1 bag of cement will be weaker than the $4\frac{1}{2}$ cubic feet of concrete with the same amount of cement. What have you to say about this statement?

The greater the per cent of sand in gravel the more the amount of cement needed. (See Iowa Method, Job Sheet No. 41.)

Job Sheet No. 45

PROPORTIONING BY SURFACE AREA

(See Engineering News-Record, Jan. 1, 1920)

The amount of the **paste** of cement and water required to coat the particles of the aggregate will **increase as** the **surface area** of the aggregate per unit volume or per unit weight increases.

Surface area per 100 pounds of different sizes of sand, gravel, and crushed stone. (See Engineering News-Record, Jan. 1, 1920, article by R. B. Young.)

For Coarse Aggregate

	Gravel, square feet surface per 100 pounds	Broken stone, square feet surface area per 100 pounds
Between 2½ and 1½ sieve =	23.6	36
" 1½ " ¾ " =	42.7	62
" ¾ " ½ " =	74.6	124
" ½ " ¼ " =	130.0	163
For Sand		
Between ¼ and # 6 sieve =	255	
" 20 " # 35 " =	1744	
" 65 " #150 " =	6975	

Evidently the **surface area increases** rapidly as the materials become **finer.**

For equal strength and consistency we must use more water and cement in fine than in coarse sands.

The **best mixture** of aggregate is claimed to be one that will reduce the **surface area** to a **minimum.**

How is this surface area determined? The aggregate is sieved as usual. The number of particles between the sieves is actually counted for a unit weight, say one ounce. Since the weight per ounce and the specific gravity of the material are known, the volume of the individual particles can be computed. Knowing the volume which may be assumed to be a sphere, the surface is then computed.

Example of Calculation of Surface Area of Aggregate

Between the No. 20 and No. 30 sieve we count 1500 particles per gram of aggregate. The specific gravity is 2.70, and therefore the weight of a solid cubic foot of the aggregate would be $2.70 \times 62.4 = 167.7$ pounds. The 62.4 is the weight of a cubic foot of water.

167.7 pounds per cubic foot = 43 grams per cubic inch.

$43 \times 1500 = 64{,}500$, the number of particles that would form a solid volume equal to one cubic inch. The average volume of one particle is $\frac{1}{64500}$ cubic inch. Assume this volume to be a sphere which has a volume $= \frac{1}{6}\pi d^3$.

$\frac{1}{6}\pi d^3 = \frac{1}{64500}$ cubic inch.

Therefore, diameter = 0.03093 inch.

Surface of sphere $= \pi d^2 = \pi\,(0.03093)^2$.

Therefore, surface of particle = 0.0030055 square inch.

Surface area per gram $= 0.0030055 \times 1500 = 4.5085$ square inches or 1422 square feet per 100 pounds of aggregate between No. 20 and No. 30 sieves.

Calculations of this kind furnish tables or charts for simple and rapid listing of aggregates. (See Figs. 21, 22.)

Proportioning Concrete by Surface Area

The measurements and calculations of surface area have been made a basis of proportioning concrete. Thus the Hydro-Electric Commission of Ontario specifies four classes of concrete:

	A	B	C	D
Minimum specified strength (pounds per square inch)	2500	2000	1500	1000
Cement required (pounds per 100 square feet of surface area of aggregate at normal consistency)	3.18	2.58	2.08	1.48
Range of water-cement ratio:				
Minimum	0.68	0.78	0.91	1.14
Maximum	0.74	0.86	1.04	1.37

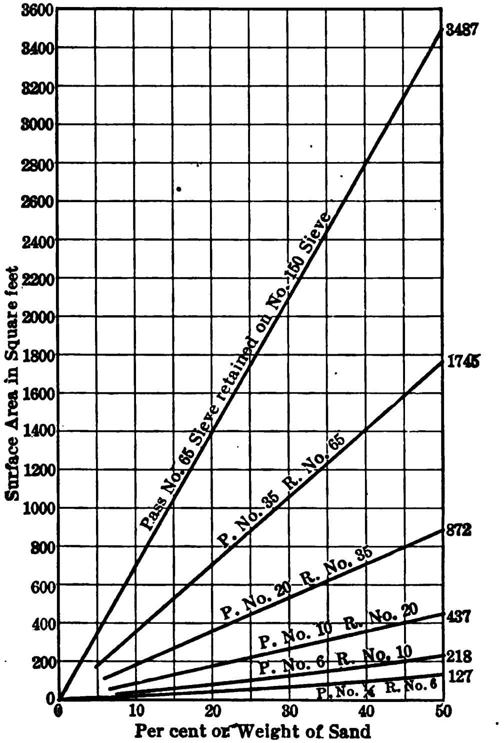


FIG. 21. RELATION BETWEEN PIT-RUN SAND GRADING AND SURFACE AREA.

(R. B. Young in *Engineering News-Record*, Jan. 1, 1920.)

The proportions fixed in the table are found by experiments in the laboratory. On the job the aggregate is tested by sieving, as it is delivered, and the surface area per 100 pounds is determined. The weight of cement required is found by multiplying the surface area by the factor in the table, for example 2.58 for a 2000-pound concrete. The amount of water is found from the water-cement ratio shown in the table.

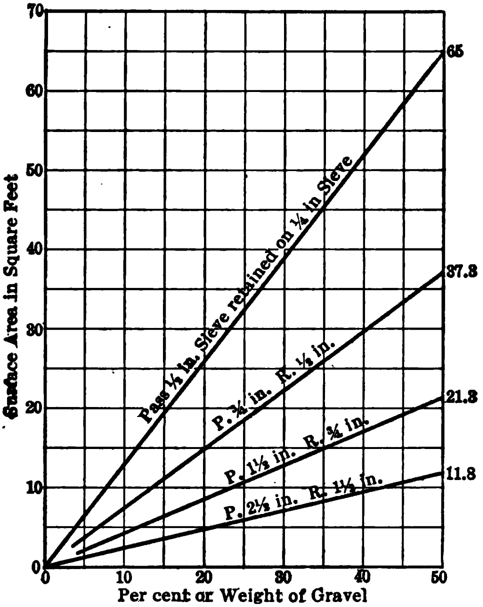


FIG. 22. RELATION BETWEEN PIT-RUN GRAVEL GRADING AND SURFACE AREA. (R. B. Young in *Engineering News-Record,* Jan. 1, 1920.)

Example, Method of Surface Area

AGGREGATE

Between sieves	Per cent retained	Surface area per 100 pounds, square feet
1½ - ¾	40	17
¾ - ⅜	18	13
⅜ - 4	9	12
4 - 8	5	3
8 - 14	7	60
14 - 28	12	200
28 - 48	8	250
48 -100	3	160
	F. M. 6.04	S. A. 715

Surface area = 715 square feet per 100 pounds aggregate.

Using 2.5 pounds of cement to each 100 square feet of surface of mixed aggregate, 2.5 × 7.15 = 17.87 pounds cement per 100 pounds aggregate. Weight per cubic foot of aggregate = 130 pounds. Cement required = 17.87 × 1.30 = 23.23 pounds per cubic foot or 1 : 4.04 of mixed aggregate by volume. With water ratio of 0.8, requires 6 gallons water per bag of cement. 1 : 4.04 of mixed aggregate will be about 1 : 2 : 2.7 of separated aggregates because there is a shrinkage when the aggregates are combined.

If the concrete turns out to be dry or too wet, water and cement are added or subtracted in the same proportion so as to keep the water ratio constant.

Professor Abrams' Fineness Modulus (see Job Sheet No. 46) has some relation to the Surface Area. Tests reported show the following relations for tested aggregates:

Surface area (per 100 pounds) (S. A.)	250	500	1000	1500	2000
Fineness modulus (F. M.)	6.5	5.75	4.40	2.90	1.50

The value of the surface-area method of proportioning is yet to be determined. Under the method the finer particles greatly influence the calculations.

Experiment on Proportioning by Surface Area

1. Sieve an aggregate of mixed sand and gravel.
2. Weigh and count the particles in one ounce of material between each set of sieves.
3. Calculate the surface area per 100 pounds.
4. Mix this aggregate with cement to furnish four sets of test pieces in the proportions of 1.5, 2.0, 2.5, and 3.0 pounds of cement per 100 square feet of surface area at a normal consistency.
5. Determine the water-cement ratio for each set.
6. Make five 6- by 12-inch cylindrical test pieces for each set.
7. Test at 7 days.
8. Report the average strength of each set.
9. Report the number of pounds of cement per 100 square feet and water ratio required for a concrete of 2000 pounds strength.

Job Sheet No. 46

PROPORTIONING BY FINENESS MODULUS

(See Job Sheet No. 27)

(See Bulletin No. 1, Structural Materials Laboratory, Lewis Institute, by Duff A. Abrams)

Professor Abrams uses the **Fineness Modulus** as an **index** of the **concrete making properties** of an **aggregate**. The Fineness Modulus is obtained thus:

Sieve a sample of the aggregate through a set of Tyler sieves, namely 1½, ¾, ⅜, Nos. 4, 8, 14, 28, 48, 100. Add the percentages retained on the sieves and divide by 100. Thus:

Sieve	1½	¾	⅜	4	8	14	28	48	100
Per cent retained	0	19	49	71	78	81	86	92	98

Sum of per cents = 574

F. M. = Fineness Modulus = $\frac{574}{100}$ = 5.74.

This Fineness Modulus is expressed by the **area** under the curve in Fig. 5, Job Sheet No. 26.

The **same F. M. is claimed to be reached** by **various mixtures** of aggregates. A mix of 1 cement and 5 combined sand and pebbles, which has a F. M. of 5.7, will have a constant strength even if the proportion of sand to pebbles changes. Thus, in mixing different sands and different pebbles we have only to preserve the F. M. constant. And also we must use the same water-cement ratio. Values of F. M. in usual cases of sand and pebbles are shown in Job Sheet No. 26.

The relation between Fineness Modulus and Strength is shown by Fig. 23. A mixture that produces a high F. M. may be too coarse or harsh for workability on the job.

Problem 46*a*. To compute the F. M. of a mixture of sand and pebbles — (*a*) The F. M. of a sand is 3.10, and of pebbles is 7.00. What will be the F. M. of the mixed aggregate with 33 per cent sand and 67 per cent pebbles?

F. M. of mix = $0.33 \times 3.10 + 0.67 \times 7.00 = 5.70$.

The rule is F. M. of mix = per cent sand × F. M. sand + per cent pebbles × F. M. pebbles.

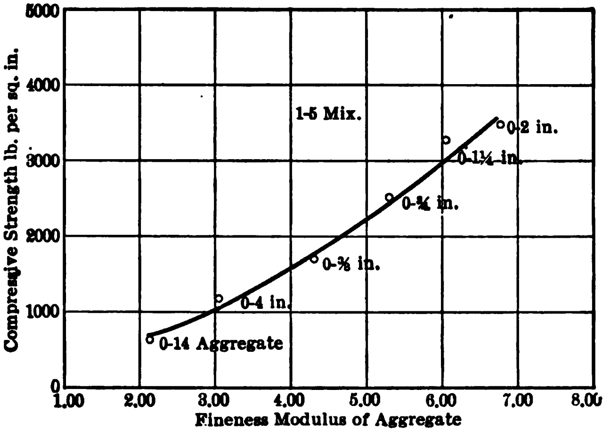


FIG. 23. DIAGRAM SHOWING RELATION BETWEEN FINENESS MODULUS OF AGGREGATE AND STRENGTH OF CONCRETE.

Problem 46*b*. What per cent of sand should be used when a F. M. of mixed aggregate = 5.25 is specified? Same materials as in (*a*).

$$\text{Per cent of sand} = \frac{7.0 - 5.25}{7.0 - 3.10} = 45 \text{ per cent.}$$

The rule is

$$\text{Per cent of sand} = \frac{\text{F. M. of coarse aggr.} - \text{F. M. of mixed aggr.}}{\text{F. M. of coarse aggr.} - \text{F. M. of fine aggr.}}$$

The diagram, Fig. 24, enables these results to be reached without calculation.

Problem 46*c*. Sand F. M. = 3.03, Pebble F. M. = 7.03. What per cent of sand for a combined F. M. of 5.54?

SOLUTION: Find (1) intersection of line 3.03 and 7.03. Draw a line from (2) F. M. of mixed aggregate at value of 5.54 through (1) to meet left-hand vertical line at (3) $37\frac{1}{2}$ per cent, which is the per cent of sand required.

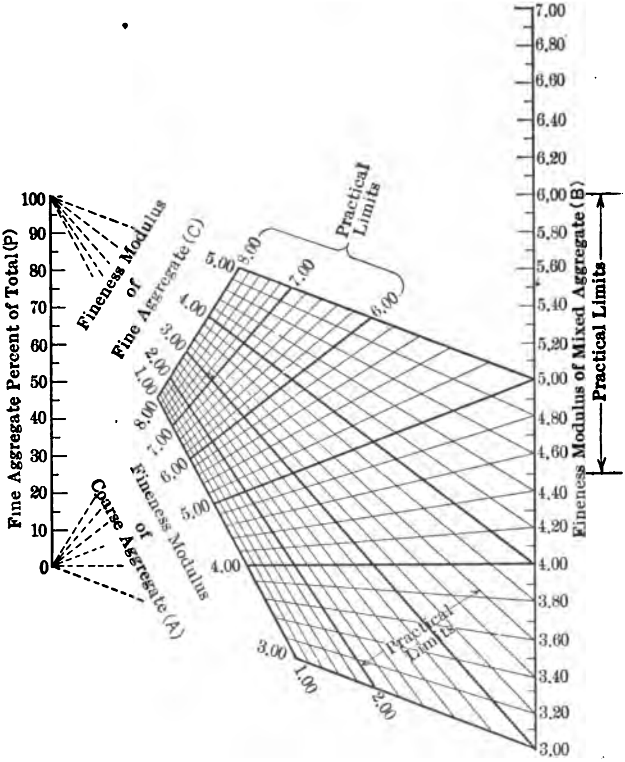


FIG. 24. DIAGRAM FOR DETERMINING QUANTITY OF SAND REQUIRED IN CONCRETE MIXES.

The Fineness Modulus of the mixed aggregate is known or specified, and the Fineness Modulus of both fine and coarse aggregate is measured. Find the intersection of the lines indicating the F.M. of the two aggregates. Draw a line from the F.M. of the mixed aggregate through this intersection until it meets the vertical scale on the left This point will indicate the per cent of sand to use.

Problem 46d. What is shrinkage and real mix of Problem 46a?

(*a*) 2 cubic feet sand and 4 cubic feet pebbles are mixed together. How many cubic feet will there be in the mixed aggregate? The shrinkage is, by experiment (see Sheet No. 29), about 14 per cent. Therefore, the mixed volume will be 6 × 0.86 = 5.2 cubic feet.

Thus a mix of 1–2–4 of 1 : 6 loose volumes will really be 1 : 5.2 of mixed aggregate.

Problem 46e. With pebbles from 1½ inches down a concrete is specified to be mixed 1–2–3½ of coarse sand and pebbles, that is 36 per cent sand, 64 per cent pebbles. However, the coarse sand is expensive and a fine sand is cheaper. What will the equivalent mix be, using the fine sand? The tests show the following:

F. M. fine sand	= 2.50	wt. = 105,
F. M. coarse sand	= 3.25	wt. = 114,
F. M. pebbles	= 7.20	wt. = 110.

Weight of mixed aggregate with coarse sand = 128 pounds per cubic foot.

(*a*) What is real mix and F. M. of 1–2–3½ with coarse sand?

$$2 + 3\tfrac{1}{2} = 5.5,$$
$$5.5 \times 0.86 = 4.73,$$
$$\text{Real mix} - 1 : 4.73.$$

Fineness Modulus of mixed aggregate with coarse sand = 0.36 × 3.25 × 0.64 × 7.20 = 5.78.

(*b*) What should be per cent of fine sand for F. M. of 5.78?

$$\text{Per cent fine sand} = \frac{7.20 - 5.78}{7.20 - 2.50} \times 100 = 30$$

$$\text{Per cent of pebbles} \qquad = \underline{70}$$

$$\text{Total} \qquad 100$$

This may also be worked out by diagram, Fig. 24.

This (*b*) is found to weigh 126 pounds per cubic foot. Since the F. M. does not change the real mix will still be 1 : 4.73.

(*c*) Calculation of proportions,

$$\begin{aligned} 5.5 \times 30 &= 1.65 \\ 5.5 \times 70 &= \underline{3.85} \\ & 5.50 \end{aligned}$$

Therefore, mix is 1 : 1.65 fine sand; 3.85 pebbles to be equivalent in strength to 1 : 2 : 3½ with coarse sand. That is, the same F. M. has been reached by increasing the pebbles. But this mixture should be tried out in the field to see if it is too coarse to work well.

Problem 46*f*. Using Fig. 25. Concrete is to be proportioned for road work with a consistency of 1.1. The strength required is 3000 pounds per square inch in compression at 28 days. The F. M. should be 5.50 for this aggregate. What shall be the proportions of cement, sand, and gravel?

(*a*) Test for F. M. and weight of gravel and sand. Example —

F. M. sand	3.25;	wt. sand	114.
F. M. pebbles	7.20;	wt. pebbles	110.

The proportion of sand in mix is $\frac{7.20 - 5.5}{7.20 - 3.25} = 42$ per cent.

(*b*) Mix 42 per cent of the sand and 58 per cent of pebbles and find weight per cubic foot of mixed aggregate. Example = 128 pounds.

The shrinkage when mixed can be assumed to be 0.86.

(*c*) Use chart (1), find intersection of vertical line upward from relative consistency of 1.10 and curved line of 3000 pounds strength; (2) From point of intersection (1) run horizontally to point 2 on heavy block line (which runs vertically through consistency = 1.0); (3) From this point 2, draw a line through (3) a value of 5.75 on slanting line marked Fineness Modulus to meet (4) on vertical axis on left at a value of 1 : 4.6. The latter is the mix of 1 cement to 4.6 parts of mixed aggregate, the real mix.

The volume of aggregate before mixing is $\frac{4.6}{0.86} = 5.35$.

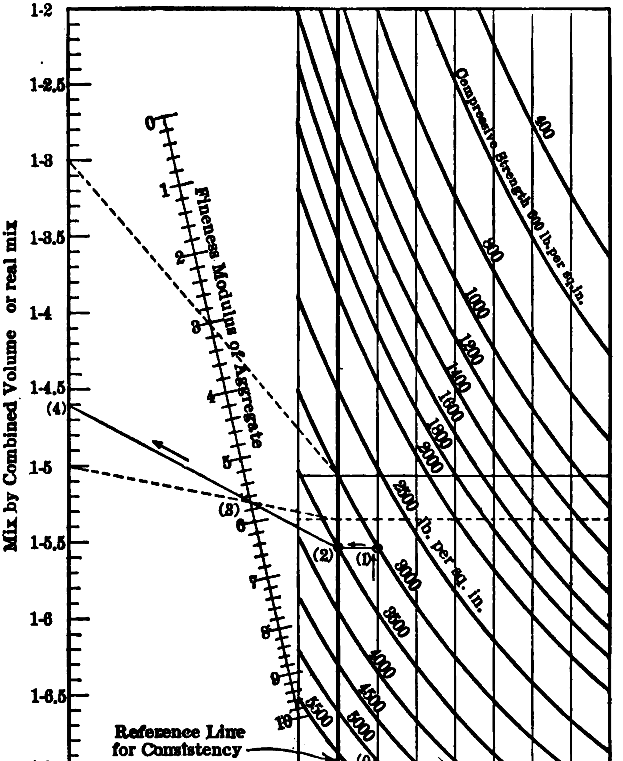


FIG. 25. DIAGRAM FOR DESIGN OF CONCRETE MIXES. See explanation in Job. Sheet No. 46.

Of this 5.35 there will be 5.35 × 42 per cent = 2.25 sand,
5.35 × 58 per cent = 3.10 pebbles,

or the mix will be 1 cement, 2¼ sand, 3.1 pebbles.

Problem 46g. This diagram enables the mix to be determined to produce the required strength when the F. M. of the aggregate is known.

Thus — A mix is to be found for a concrete road. Consistency is 1.10, strength is 3000 pounds.

Solution: This F. M. of the mixed aggregate is 5.54 with 37½ per cent of sand (see Problem 2).

Through point (1) draw a line horizontally to point (2) and then from (2) through point (3) at F. M. 5.54 to find (4) at 1 : 4.9 which the mix of 1 cement to 4.9 parts of the mixed aggregate. This will be $\frac{4.9}{0.86} = 5.7$ separate parts or practically 1–2.1–3.6.

The value of the F. M. as an index of the consistency making properties of the concrete is yet to be determined. The above study will fix the elements in the understanding of the student.

Figs. 23, 24, and 25 are reproduced with the permission of Professor Duff A. Abrams from Bul. No. 1, Structural Materials Laboratory, Lewis Institute, Chicago.

Job Sheet No. 47

VOL. I, CHAP. VI, PAGE 124, FIG. 64

TEST THE RESISTANCE THAT A PLAIN STEEL ROD OFFERS AGAINST PULLING OUT FROM CONCRETE

(Provided laboratory is available)

The length to embed an anchor or a dowel is to be determined.

Instruction: Consult Job Sheet No. 32 and make three cylinders of 1 : 2 : 4 concrete with rods ½ inch in diameter, embedded in the axis of the cylinder to a depth of 5, 10, and 15 inches respectively. Put them in damp place to cure for 28 days.

Bed the cylinder in plaster of Paris, or on blotting paper, on the upper head of the testing machine with the rod in the axis of the testing machine. Grip the steel rod with the pulling head. Lay off a 3-inch gage length on the rod. Determine the diameter of the rod at three sections. (See Fig. 26.)

1. Is the cylinder properly bedded? Why must it be?
2. Is the steel rod in the axis of the testing machine? Why must it be?
3. Is the grip of the pulling jaws even and is the grip the entire length of the jaws? What will happen otherwise?

Operate the testing machine in slow speed, pulling the rod from the cylinder. Keep the beam balanced. Observe the stretch of the rod. Read the maximum load and the load while the rod is moving out. Measure the diameter after withdrawal and the gage length.

1. Has the rod begun to show signs of yielding by skin-stretching?
2. How much has the rod stretched or diminished in diameter?
3. What was the load per square inch on the rod at the maximum load?

4. What was the length of embedment of the rod? Its surface area? The "bond" per square inch, assuming the rod to resist uniformly along the length?

Bond is the stress of resistance per square inch on the embedded surface of the rod at the maximum load. Before the bar slips there are two actions: (1) The grip caused by the shrinkage of concrete. (2) The frictional resistance caused by unevenness of bar. At the maximum only the second acts. (See Fig. 64, Vol. I, page 126.)

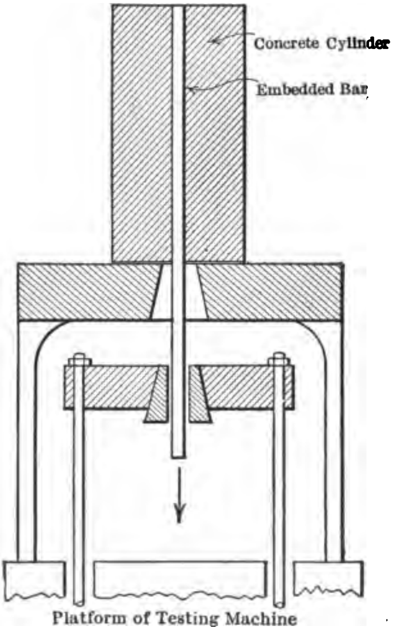


FIG. 26. DIAGRAM SHOWING METHOD OF MAKING TEST OF BOND BY PULLING BAR FROM CONCRETE CYLINDER.

1. What would be the length of the embedment or anchorage so that the rod would break before it would pull out? How many diameters is this length?

Did one of the bars break before it pulled out? If so, what was the relation of length of embedment to diameter of rod? Is it likely that the rod resists uniformly along its length?

2. Has some of the mortar adhered to the pulled out rod?

3. Would the bond be less if the rod had a glass-smooth surface?

4. Would the bond be greater if the rod had projecting lugs or artificial deformation? (See Table IX, Vol. I, page 85.)

Record the value of the bond for plain and deformed rods in standard texts and compare the results with your tests.

5. What difference in the value of bond would be found if the concrete were richer than 1 : 2 : 4 and older than 60 days?

6. What section will offer greatest bond in a steel rod, a circle, a square, or a rectangle?

7. How many diameters should the plain steel rods of your tests be anchored in 1 : 2 : 4 concrete to develop the strength of the rod?

8. Compare this with standard rules.

Job Sheet No. 48

VOL. I, CHAP. VI, PAGE 127, FIGS 65 AND 66

TEST THE STRENGTH OF ANCHORAGE BY HOOKS AND BENDS

Bend the end of a $\frac{3}{4}$-inch round bar through an angle of 180 degrees with a diameter of 4 times the thickness of the bar, and a short straight piece 3 inches long beyond the bend.

Bed the bar 8 inches in a concrete cylinder as described in Job Sheet No. 47. Apply a pulling test as described in Job Sheet No. 47.

1. Did the bar pull out?
2. Did the bar yield before pulling out?
3. Compare the anchorage of a straight bar embedded —— times the diameter with the anchorage of the bent bar.
4. Repeat this test with a bar the end of which is bent at right angles for 4 times the diameter.
5. Is this as good an anchorage as the hook? Is it to be recommended?
6. Repeat the test with a nut and 3-inch washer on the end of the rod.
7. Does the bar slip in the concrete before the nut takes hold?
8. Is this method of anchorage (6) to be recommended?

Job Sheet No. 49

VOL. I, CHAP. IV, PAGE 85, FIG. 64, TABLES IX AND XV

SKETCH THE FORMS OF VARIOUS SAMPLES OF DEFORMED BARS AND COMPARE THEM

Secure samples of deformed bars, such as simple lug bar, corrugated, cup, Havemeyer, twisted square. (See Table IX, Vol. I.)

Deformed bars have a **greater bond** than plain bars because of the additional **bearing resistance** of the **projecting lugs**. The lugs bear against the concrete. The concrete tends to shear out between the lugs.

1. What would be the different actions of two lug bars, (*a*) one with the lugs spaced close like a threaded screw, and (*b*) one with lugs far apart, say 10 inches?

2. Does your examination show the **area** of the **cross section** of the deformed bar to be **equal** at all sections?

3. How much excess metal is used in the lugs to increase the bond?

4. Examine a twisted rod. Draw a longitudinal section of this rod.

5. Is there a wedging action in (4)? Is the wedge flat?

6. Examine the corrugated bar. Draw a longitudinal section.

7. Is the wedge **steep** or **flat** in (6)?

8. Which bar would **slip farthest** before coming to a bearing, (4) or (6)?

9. List the bars in order of uniformity of cross section and in order of bluntness of wedge.

Job Sheet No. 50

VOL. I, CHAP. VI, PAGE 189

TEST REINFORCING STEEL FOR BENDING

A simple test for reinforcing steel is its ability to take a bend without cracking.

Reinforcing steel is generally manufactured from **new billets,** which are **poured directly** from the furnace, and then **rolled** into bars. The quality of the steel may be of **structural** grade, or of a **hard** grade. The latter has a high elastic limit, and greater ultimate strength, but has less ductility.

A large amount of reinforcing steel is made from worn-out **steel rails** which are **rerolled** after having been heated in a furnace. The first pass cuts the rails into three parts, the head and web and the base. These are then rolled to the desired size. Twisted bars from hard steels are twisted hot. The **rerolled** rail steel is of **high strength,** and **small ductility.** Sizes of one inch and under can be bent freely.

The simplest field test for reinforcing bars is the **bending test.** The specifications are as follows:

BEND-TEST REQUIREMENTS

Thickness or diameter of bar	Plain bars			Deformed bars			Cold-twisted bars
	Structural-steel grade	Intermediate grade	Hard grade	Structural-steel grade	Intermediate grade	Hard grade	
Under ¾ in.	180° $d=t$	180° $d=2t$	180° $d=3t$	180° $d=t$	180° $d=3t$	180° $d=4t$	180° $d=2t$
¾ in. or over ...	180° $d=t$	90° $d=2t$	90° $d=3t$	180° $d=3t$	90° $d=3t$	90° $d=4t$	180° $d=3t$

EXPLANATORY NOTE. d = the diameter of pin about which the specimen is bent;
t = the thickness or diameter of the specimen.

1. Should the bar be gripped or left free to move at one end?
2. Is a bend made quickly more severe than a slow bend?
3. Will steel bend better on a hot than on a cold day?
4. How large should a bar be before it should be heated for bending?
5. What kind of steel is most likely to be injured by heating?
6. Does the bar pass these specifications?

Job Sheet No. 51

VOL. I, CHAP. VI, PAGE 132, PLATE XIV AND FIGS. 70–73

STUDY CONCRETE FABRIC REINFORCEMENT

Fabrics of wire are made of two sets of wires, secured at their intersection by **welding** or **wrapping** or **tying.** One set of wires, running lengthwise, is heavier than the other and called **carrying** wires. The lighter set crosses these and serves to distribute loads, and supplies **transverse** reinforcement. These fabrics are used for **short span slabs,** and for **temperature reinforcement** in pavements and walls.

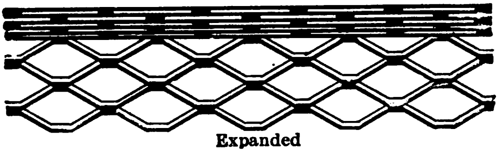


FIG. 27. DIAGRAM SHOWING METHOD OF EXPANDING METAL.

Other fabrics are **reticulated,** like expanded metal. A sheet of soft metal is slitted and is then pulled until the slits open up into diamond-shaped spaces. (See Plate XIV, Figs. 70–73, Vol. I, and Tables XVI, XVII; see Fig. 27, Vol. II.)

Wire Fabric

1. Select samples of wire fabric to include the following: Clinton wire cloth, triangle mesh, and a fabric tied at the intersections. Cut out short length of the wire, both longitudinal and transverse, and pull them in the testing machine. Measure the diameters. Report the ultimate strength. Consult table of wire gages. What grade of steel is it?

2. How many square inches of cross section of steel are there per foot of width in each of the two directions? If

some of the wires slope at an angle, how would you allow for this slope?

3. Check the weight per 100 square feet of surface.
4. What proportion of the area of cross section of the metal is in each direction?
5. What widths and lengths are available?
6. How is the material shipped?
7. For what spans and loads is wire fabric recommended in slabs? When is it economical to use bars?

Expanded Metal

Select a piece of expanded metal and test and measure it as directed above for wire fabric. Make a similar report.

1. How is the expanded metal designated? What does 3–13–10 mean?
2. What widths and lengths are available?
3. How is it shipped?
4. Comparing wire fabric and expanded metal. What is the relative amount lost in providing laps in a job 50 feet wide and 400 feet long?
5. Which of these types is most easily set and held to place in concrete?

Self-Sentering Fabrics

Fabrics are made which combine a **light reticulated mesh** and **heavier ribs.** These are used as **centering** for roofs and for **partitions,** etc. The mesh is fine enough to retain the concrete and the ribs are strong enough to hold its weight without wooden forms on short spans up to 4 feet. A plaster finish is applied on the lower side.

1. Secure samples such as Hy-Rib, Corr-Mesh, Self-Sentering and Chanelath.
2. In what sizes are these available?
3. What is the relative weight of metal in the mesh and in the ribs?
4. Which type provides the most leverage from the center of the metal in the ribs to the level of the mesh?

5. Study the catalogues and find out for what spans the material is recommended.

6. Study the catalogues and determine if any of these wire fabrics or expanded metal would supply the same cross section of steel as the steel bars provided in the Lawlor Building for the following:

5-inch slab.
10-inch slab.
Stair slab, Section 9, Sheet 2.

7. What is the relative weight of metal in the fabric and in the bars per square foot of slab surface?

8. Which would you use?

The specifications of the Indiana State Highway Commission are:

"**Reinforcing Materials.**—The reinforcement for the concrete pavement shall consist of steel fabric having an effective weight of not less than forty (40) pounds for each one hundred (100) square feet. A standard "A. S. T. M." test bar shall develop an ultimate tensile strength of not less than seventy thousand (70,000) pounds per square inch, and shall bend one hundred and eighty (180) degrees around one (1) diameter and straighten without fracture. The main members shall be spaced not more than six (6) inches apart and shall have an effective cross-section area of not less than six one-hundredths (0.06) of an inch per lineal foot of pavement length, and the cross-members shall be spaced not more than eight (8) inches apart. The material shall be furnished on the work in flat sheets, of a length equal to four (4) inches less than the width of the pavement unless otherwise permitted, so constructed that they shall retain their original shape during the necessary handling. These sheets shall be free from excess rust, scale, paint or coating of any character which will tend to destroy their bond with the concrete."

Job Sheet No. 52

VOL. I, CHAP. VI, PAGE 114, FIG. 55, TABLE XIV

STUDY NAILS

Look up article in Kidder's "Building Construction and Superintendence," Vol. II, and read article on Builders' Hardware. Secure catalogue of Builders' Hardware. Get samples of nails from hardware store.

1. Examine samples of cut nails, in three varieties; namely, **common, finish,** and **casing**; and compare them with description and process of manufacture.

2. Which will be more **durable,** iron or steel nails? Why?

3. Drive several cut nails in a pine board, near the end, some with long side of point along grain and some across grain. Which will be likely to **split** the wood?

4. Get samples of brads, clout nails, lath, shingle, and slating nails. What elements fix the design of these nails?

5. How are wire nails manufactured?

6. Drive several cut and several wire nails of same pennyweight into hard maple. Which will be more likely to **bend** under the hammer? Which is **harder to drive?** Which holds more firmly, after having been slightly loosened, as under vibration?

7. Drive several wire nails in pine stud, some in side and some in end. Estimate the relative resistance to withstand.

8. Will nails that have rusted in the wood draw out harder than newly driven nails? What if the wood has decayed?

9. What is advantage, if any, of **barbed** nails? When can **cement-coated** nails be used?

10. Nails are classified by **pennyweight** and written 2*d.*, 4*d.*, etc., up to 100*d.* This has come down from old times when

nails were classified by price per 100. Thus 8*d*. was 8 pence per 100 nails.

11. What is the distinction between a **nail** and a **spike**?

12. What size nails would be used in the following?

    Framing two 2 × 4's together.
    Rough sheathing on studs.
    Sheathing S–2–S on joists.
    2-inch planks.
    Tongued and grooved flooring on joists.

13. Would it be advisable to use cement coated or barbed nails in form work?

14. When can **double-headed** nails be used?

15. When are copper, zinc, and galvanized nails used?

16. How many pounds of nails, and what pennyweight will be required for the following of the Lawlor Building?

    Sheathing for roof slab.
    Column forms.

Sizes of nails commonly used are:

	Sizes in pennies
Framing	10, 20, 40, 60
Sheathing, rough flooring, bridging	10
Flooring and ¾ ceiling	8 and 10
Inside finish	6 and 8
Clapboards	6
Shingle, slate, lath, etc.	3 and 4

SECTION IV

FORMS — Sheets 53–59

Job Sheet No. 53

VOL. I, CHAP. VI, PAGE 112

STUDY LUMBER FOR FORMS

(See Vol. I, Fig. 66, Plates X, XI, and XII.)

The **cost of forms** is a **large** part in the cost of a reinforced concrete building. They should be designed as carefully as the concrete work.

Visit a lumber yard and mill in the vicinity. Determine the species of lumber available for form work.

1. Which is the best species, from standpoint of quality and price, for the following: sheathing, studs, posts, fine cornice work, wedges, joists.

Consider white pine, Norway pine, spruce, short leaf, southern pine, hemlock, or such as are available.

2. What qualities and kinds are best for sheathing? What is the advantage of beveled edges? When can unplaned lumber be used?

3. Find pieces showing warping, shakes, rot, cross-grain, loose knots, shelly grain on the face wane. American Society for Testing Materials, 1919, Year Book.

4. What defects in finished work will result from rough lumber, green lumber, kiln-dried lumber, loose knots, curved edges? What danger from cross-grain, shakes, large knots?

5. Which wood will be most likely to split under nailing?

6. What is the additional cost of lumber S–4–S over rough lumber? How does S–4–S save expense on the job?

7. What is the thickness of a 1-inch stock dressed two sides?

8. What size stock is used for floor sheathing, for column and wall sheathing, for sides of beams and girders, for beam and girder bottoms, for column forms?

9. To what pieces do the following terms refer?

Lagging, surfacing, joists, girts, studs, posts, sills, shores, bracing, stops, ledgers, cleats, ribband, post cap, column yoke, clean-outs.

10. Specify the species and thickness of stock for surfacing that you would use in the Lawlor Building for the following:

Stairs, Section 9.
10-inch slab, Section 9.
Wall in basement.
Coal opening.
Retaining wall.
Columns 1–6.
Parapet.
Roof slab.
Roof beams.

11. Forms should be oiled to prevent the concrete from adhering. A mixture of kerosene and linseed oil is used. Where concrete surfaces are to be plastered use water on surface forms. Centers of girders and beam forms should be raised about $\frac{3}{8}$ inch for every 10 feet span to allow for sag.

Forms must be well braced. Forms must be cleaned after use.

Job Sheet No. 54

Vol. I, Chap. VI, Page 112

PROBLEMS IN ESTIMATING FORM LUMBER

1. How many board feet (B.M.) are there in a 2 by 6-inch by 14 feet? A 2 by 4-inch by 16 feet? 2 by 10-inch by 12 feet? 1 by 4-inch by 10 feet?

2. How many feet B.M. in a platform built of 1-inch sheathing which is 8 feet by 16 feet?

3. How many feet B.M. would you order of 1 by 6-inch D. & M. for a concrete wall form 4 feet 2 inches high and 30 feet long?

4. If the studs in problem 3 were spaced 2 feet centers and extended 1 foot above the sheeting, how many feet B.M. of 2 by 4-inch would you order?

5. If at each stud every board had two 6*d.* nails in it, how many pounds of nails would be necessary?

6. How much lumber in the 2 by 8-inch planks and 2 by 4-inch cleats and how many pounds of 10*d.* nails would be necessary to build an 8 by 16-foot concrete mixing board? Cleats to be spaced 2 feet centers?

7. A concrete foundation wall for a building 16 by 24 feet is to be 3 feet high. Using 1 by 6-inch D. & M., 2 by 6-inch studs spaced 20 inches centers, and 8*d.* nails, estimate the materials required, exclusive of stakes and braces.

Job Sheet No. 55

STUDY TOOLS AND MACHINERY FOR WOOD WORKING

1. List the tools necessary to do properly the carpenter work on a concrete construction job.

2. What is the proper size of cross-cut saw for form building job?

3. What is the proper size of rip saw for form building job?

4. State the proper uses of the following carpenter's tools in concrete form work: (*a*) Cross-cut saw; (*b*) rip saw; (*c*) steel square; (*d*) try square; (*e*) T bevel; (*f*) hammer; (*g*) hatchet; (*h*) carpenter's apron; (*i*) carpenter's pencil; (*j*) 2-foot rule; (*k*) fore plane; (*l*) jack plane; (*m*) chisels; (*n*) brace and bit; (*o*) spirit level; (*p*) chalk line and chalk; (*q*) plumb bobs; (*r*) wrecking bars; (*s*) 8-inch pliers.

5. What is meant by the term "8 point" "6 point," etc., when used in describing a particular saw?

6. What are the differences between a cross-cut saw and a rip saw?

7. Why is a coarse saw used for ripping?

8. Will a rip saw cut across the grain as well as with the grain? Why?

9. Should a hand saw be grasped with a strong grip or natural grip?

10. Is it necessary to exert pressure on a hand saw in order to make it cut properly?

11. What should be done with the saw between cuts, assuming that it is necessary to dispose of it temporarily?

12. What is meant by "set" in a saw?

13. Is it always necessary to have "set" in a saw?

14. Does it require more set for green and wet lumber than for dry lumber?

15. Should a saw be laid away while wet?

16. What might be the damage to a steel square resulting from a fall or from being stepped on?

17. What is the most practical size for a steel square? for a try square?

18. Should a claw hammer be used for pounding on heavy steel, stone, concrete, or brick? Why?

19. What might be the effect on a claw hammer or hatchet if attempts were made to draw large nails?

20. Why should a carpenter's apron be worn by a workman even when not engaged in nailing?

21. Where is a good place to carry the hammer?

22. What adjustment should be made to a plane when the planing work is completed?

23. How should the plane be disposed of between cuts, assuming that it is necessary to dispose of it temporarily?

24. Should a long or a short plane be used when working on a crooked piece of lumber? Why?

25. How should the plane be handled on the return or back stroke?

26. What are three ways of determining whether or not the plane is sharp?

27. How much is a mechanic's efficiency lowered by reason of tools in poor condition?

28. How would you prepare metal tools for storage in a damp place or for an indefinite time?

Job Sheet No. 56

Vol. I, Chap. VII, Page 80, Fig. 95

FORM DETAILS FOR PLAIN CONCRETE STAIRS

1. Sketch all the panel details required for these stairs.
2. Estimate the lumber required.
3. Build the form.
4. How many nails did you use?
5. What is the relation of the nails by weight to the board feet of lumber?
6. Cast the bottom tread.
7. Will you leave it rough and cast a finish later or will you cast the finish at the time the mass concrete is placed?
8. Which is the better method?
9. If the stairs are to be finished by rubbing later, write a specification for the construction of these stairs including all details.

Job Sheet No. 57

Vol. I, Chap. V, Page 89. Fig. 38

BUILD A TWO-WALL FORM

Consult pamphlet on "Concrete Foundations," by Portland Cement Association.

1. What size of uprights should be used in a two-wall form, 4 feet high and 10 feet long?
2. What is meant by bottom plate? Studding? Bracing?
3. How many nails should be used to nail siding to studding?
4. How many nails should be used to nail the siding to these uprights of studding?
5. What size of bracing should be used in this form?
6. Does a brace hold more when nailed to the studding or when placed against it?
7. What size of nails should be used to fasten studding to bottom plate?
8. What size lumber should be used to make the cross piece which holds the top of the two walls together?
9. How many and what size of nails should be used to make this cross piece?
10. How far apart should the studding be set in a wall 4 feet high and 10 feet long?
11. What size of nails should be used to close the end of form?
12. How many nails should be used in each 8-inch board to close end of wall?
13. How far apart should the braces be in this form?
14. Where is the first wire placed in a form of this size?
15. What effect does twisting the wire have on the form?
16. Where is the first studding placed in a form with the ends closed?

17. Should a nail be driven at right angles to the side? Why?
18. How many different sizes of nails used in this form?
19. What kind of lumber should be used in this form?
20. Give two reasons for using this kind of lumber.

Job Sheet No. 58

Vol. I, Plates X, XI and XII. Pages 120 and 121

STUDY ASSEMBLY OF FORMS AND DETAILS FOR THE LAWLOR BUILDING

1. What size of material is used for

   (*a*) Slab panels — marked S?
   (*b*) Beam sides — marked B?
   (*c*) Beam bottoms — marked BB?
   (*d*) Column sides — marked C?
   (*e*) Posts and braces?
   (*f*) Girts and beams?

2. How many cubic feet of concrete are carried on one beam support?

3. Make a $\frac{3}{4}$-inch scale detail section through a roof beam.

4. Sketch the construction at the point when the slab panel connects with the beam side.

5. Note the method for yoking the column forms. How could this have been done otherwise?

6. Note the method used for bracing the beam sides. Is this necessary? Why?

7. Is it necessary to build forms for the ends of slabs and beams resting on brick walls? What reason do you have for your answer?

8. Make a detail of the beam sides and beam bottom of a roof beam framing with a column on one side and a brick wall on the other.

9. Build this form.

Job Sheet No. 59

VOL. I, FIG. 29a. PAGE 63

DRAW UP ASSEMBLY AND PANEL DETAILS FOR STEPPED FOOTING

1. What is an assembly?
2. How are the assembly and details used in the job?
3. Is any connection necessary between the two drawings?
4. What projections will you use for the assembly? What for the panel details?
5. What scale will be convenient for your use?
6. Determine upon the size and grade and surfacing of lumber necessary for this form.
7. Build the panels from your details.
8. Erect the forms.
9. Compare your drawings with the form and correct them if necessary.

SECTION V

MIXING CONCRETE — Sheets 61–71

Job Sheet No. 61

VOL. I, CHAP. IV, PAGE 80, FIGS. 34, 35

MAKE UP TEMPLATE FOR DOWEL PLACING

Dowels are placed in a footing to tie in the columns. (See Job No. 47.)

A column reinforced with four ⅞-inch rods is to be cast upon a spread footing, 6 feet square and with a plane cap surface 2 feet square. The column is 16 inches square.

1. What is meant by the plane cap surface?
2. How many dowels will you use? Of what size and length? How far anchored in concrete?
3. Where will these be located with respect to the column steel?
4. Draw a plan and elevation of the footing and column to ½-inch scale.
5. Draw a detail plan and elevation of your template.
6. Construct the template.
7. Observe and report upon the use of this method in some nearby building in the process of erection.

Job Sheet No. 62

Vol. I, Plate II

BUILD MACHINE BASE AND SET ANCHOR BOLTS

(Consult "Drawing of Planer Base," Vol. I, Plate II, Section 12.)

1. What is the length, width, and depth of base?

2. How far above the wood block is the top of this base?

3. What mix of concrete? Consistency?

4. Sketch the forms. Specify kind of surfacing and lumber.

5. Obtain plan of anchor bolts and set them with template.

6. Sketch and make this template.

7. Will anchor bolts be set in concrete direct, or will they be set in sleeves?

8. What is the purpose of these sleeves? How will the lower ends of the bolts be anchored? Sketch the washers or other device.

9. How far will these bolts project above the base? How will the machine be set down over these?

10. Can you suggest a method of attaching the bolts by which they can be removed and then set through the holes in the base of the machine, thus avoiding the blocking up of the machine?

Job Sheet No. 63

Vol. I, Chap. V, Page 58

PLACE DRY CONCRETE IN WALL FOUNDATION

For the wall foundation the concrete is fairly dry, drier than for walls and wetter than for a sidewalk base. Mortar should flush to the top after a vigorous tamping.

1. What precaution have you taken to prevent the soil from washing down?
2. Read pages 58 to 59 of the text, Vol. I, and carry out instructions.
3. See that the bottom of the trench is to grade.
4. Has the bottom of the trench been wetted down? When is this necessary?
5. Will a stop board be needed?
6. Will the soil bank without bracing?
7. What mix is specified?
8. Is the concrete being thoroughly tamped?
9. Is the foundation of the required thickness, and with a level surface?
10. When is it allowable to throw in large stones in concrete while it is being placed?
11. Sketch a diagram of the arrangement of material and mixing board, and report where labor could have been saved in the operations.

Job Sheet No. 64

VOL. I, CHAP. V, PAGE 100, PLATE VIII

USE OF CONCRETE MIXER

Mix a Batch of Concrete in a Batch Mixer of Drum Type

(Read also Job Sheets Nos. 65 and 66.)

1. Inspect the mixer and note the following points.

2. Is the mixer **clean** inside or caked with old concrete? Is the drum **tight?**

3. Are the **blades worn?**

4. Has the mixer an automatic water measuring tank?

5. Is the organization such that the materials are coming to the mixer with regularity?

6. How many cubic feet do the wheelbarrows hold? Have you checked this with a 1-cubic-foot measuring box? How many bags of cement are used to ____ wheelbarrows of sand and ____ wheelbarrows of stone?

7. What is the proportion of the mix?

8. Inspect the **mixing** of the concrete.

9. Are the **proper proportions** of the cement and aggregate delivered to the mixer?

10. In what order are the cement, sand, and coarse aggregate put in hopper? How **long** does it take the charge to travel to the mixer from the hopper?

11. What is the diameter of the drum?

12. How many turns per minute does the drum make?

13. What will happen if the drum turns too fast? Too slowly?

14. Is the drum run at a proper speed? (See Mixer Catalogue.)

15. What proportion of the volume of the drum is filled with concrete?

16. How has the amount of water been measured?

17. Is the amount of water **uniform** in the batches? How many gallons of water are used for each bag of cement? Describe the consistency of the concrete.

18. How many minutes has the concrete been mixed?

19. Is this time long enough? (See Vol. I, page 103.)

20. Is the concrete running from the mixer uniformly? (See Job Sheet No. 65.)

21. Is the concrete too **wet** or too **dry?**

22. Does the mixer **clear** itself? Does it **spill** concrete?

23. How often does the operator **wash out** the mixer?

24. How long does the mixer take to **discharge? How many batches** of concrete are delivered each hour?

25. What is the **output** of the mixer in cubic feet per hour?

26. Has the mixer been **flushed out clean** after the job is completed?

Extracts from the Standard Specifications and Contract of the Indiana State Highway Commission of 1919:

"**Mixing Concrete.** — Concrete shall be mixed thoroughly in a batch mixer of approved type for a period not less than one (1) minute after all the materials are in the drum, and during this period the drum shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

"When permitted, hand mixing shall be done on a watertight wood or metal surface of suitable size. The cement and fine aggregate shall be mixed without the addition of water until a mixture of uniform color is produced. The coarse aggregate shall be spread over it, and the whole turned once, then water shall be added in sufficient quantity to produce the desired consistency and the whole mass turned not less than six (6) times. Hand mixed batches shall not exceed one-half ($\frac{1}{2}$) of a cubic yard."

Job Sheet No. 65

VOL. I, CHAP. V, PAGE 100

CORRECT THE CONCRETE WHEN MIX IS NOT NORMAL

(The concrete will at times leave the mixer in an improper condition.)

1. Do the **materials separate,** that is, does the mortar leave the coarse aggregate when the concrete is being placed?
2. If so, correct this by the use of fine sand and cement.
3. Does the **coarse aggregate sink** below the surface of the concrete while in the barrows?
4. See if the use of less water will correct this.
5. Is the mix taking **more cement** than was expected?
6. See if the use of more coarse sand or coarse aggregate will correct this.
7. Is the concrete **uniform** in appearance?
8. If not, run the mixer a longer time.
9. Does the mixer **clean** itself when discharging?
10. How often does the operator **flush out** the mixer?
11. See that the mixer has been completely flushed out when the job is finished.

Job Sheet No. 66

VOL. I, CHAP. V, PAGE 100, PLATE VIII

CONSULT CATALOGUES OF CONCRETE MIXERS AND INSPECT MACHINE IN FIELD

(This Job Sheet may be used in connection with No. 65.)

Concrete mixers of the batch type (1) receive the cement, sand, and broken stone, (2) add water and mix the mass by the action of the interior blades or the shape of the drum, in a manner that reproduces the action of the shovels in hand mixing, and (3) discharge the mixed concrete. The following job sheet will help the worker to understand the operation of several of the types of mixers described and pictured in the catalogues:

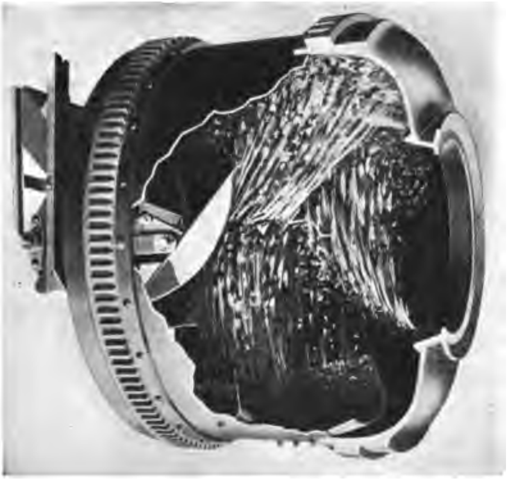


FIG. 28. INTERIOR OF KOEHRING CONCRETE MIXER.

1. What is the type of mixer, batch or continuous?

2. Does the drum discharge by tilting or by a spout which catches the concrete inside the drum?

3. How is the mixer loaded?

4. What is the shape of the drum?

5. Is the cutting and mixing of the concrete done by interior blades or by the shape of the drum acting upon the concrete?

6. Describe the progress of the materials through the drum, listing the different actions of cutting, picking up, lifting, and returning to the beginning of the trip through the mixer, and state the agency by which these motions are accomplished?

7. As far as you can, watch the action of the mixer upon the concrete.

8. Has the mixer an automatic measuring tank?

9. Has the mixer an automatic time lock to insure that the concrete is mixed for the proper time?

10. How are the steel blades fastened to the drum?

11. How is the drum constructed?

12. What is the thickness of the drum metal?

13. Is the inside construction likely to pocket the concrete?

14. What is the horse power of the motive unit?

15. How long does it take the drum to discharge?

16. What is the recommended speed of the drum? How will a change of speed affect the action of the mixer on the concrete?

Job Sheet No. 67

Vol. I, Chap. V, Page 103, Figs. 49–54

PLACE WET CONCRETE IN A PLAIN WALL

(Consult "Concrete Engineers' Handbook," pages 72–76)

1. If new concrete is being placed on old, is there **scum** on the old surface? (If so, how must the surface be prepared?) (See Job Sheet No. 70.)
2. Are the forms **tight** and **well braced?**
3. Should the concrete be spread along the length of the wall or placed in one spot and allowed to flow to place? Which is better?
4. Can a layer be placed all around the wall? If not, where will you place the stop board? (See Job Sheet No. 68.)
5. Does any of the concrete coming to the work show signs of an **initial set?** Would you use concrete that had been on the board for more than 45 minutes? (See Text, Vol. I, page 109.)
6. Is the concrete being **spaded** between the forms and back from the faces of the forms? What good will this do?
7. Will **tapping** the forms improve the job?
8. Are the forms leaking or yielding?
9. Is there **excess water** on top of the concrete? Should there be? How can this condition be corrected? (See Vol. I, page 108.)
10. Does the concrete hold together or are there **pockets** of fine or coarse material? What would cause these pockets? What would you do to prevent them?
11. What provision has been made for **union** between this day's work and tomorrow's? (See Job Sheet No. 68.)

12. Will the finished work need protection from the weather?

13. Sketch a diagram of the arrangement of materials and mixer or mixing board in relation to the wall, and report where labor could be saved in taking material to the mixer or concrete to the wall.

Job Sheet No. 68

Vol. I, Chap. V, Page 105, Fig. 52

BUILD STOP BOARD IN WALL FORM

1. The stop board is used to furnish a definite joint between one day's work and the next. This joint will present a better appearance than a random seam.
2. What purpose will be served by the tongue and groove?
3. What length will the wall have before expansion and contraction will be great enough to demand provision for taking up movement at this joint? In this case what filling material will be placed in the joint? Sketch the joint.
4. Construct the stop board and set it in place.
5. Slice the concrete well in around the tongue.

Job Sheet No. 69

See Figs. 137, 138, Vol. I, Chap. IX, Page 215

CONSTRUCT COAL CHUTE AND SET FRAME FOR COVER

The best method will be to form and cast the side and end walls, and slab, at the same time as the building walls. The bottom can later be constructed like a sidewalk.

Excavate trenches for side walls of chute and for end wall wide enough to allow forms for the 12-inch wall on the sides. Provide side pockets for slab. The forms for the end wall should be built for a section as in Fig. 138, Vol. I.

The side walls are reinforced with $\frac{5}{8}$-inch Ø rods spaced 6 inches apart in both directions on the face next to the chute. The bars should be wired together as a frame and set in. The horizontal bars should be bent around into the end wall and the wall of the building. A sheet of wire fabric or expanded metal will serve the purpose.

The forms for the walls of the chute should connect with the walls of the building and all be poured together.

The angle iron frame should be fastened to the inside of the forms, and anchors inserted through holes bored in the frame as shown in Fig. 137. A trowel should be used to shove the mortar up to a firm bearing under the frame. Later on when the forms are removed construct the bottom of the chute like a sidewalk.

Job Sheet No. 70

Vol. I, Chap. V, Page 108

BONDING NEW CONCRETE TO OLD

New concrete is bonded to old concrete (1) when the concreting is resumed the next day, (2) when a top is placed on a sidewalk base that has set, and (3) when patches or repairs are made on broken surfaces.

New concrete must be united to a **clean surface,** free from dust and fine scum. Ask the instructor to submit samples of the formation of laitance, or the scum that rises to the surface of concrete which prevents proper bonding of new concrete.

Place new concrete on concrete deposited the day before.

1. Examine the old surface.
2. Was the former concrete sloppy or dry?
3. Will sloppy concrete produce more scum than dry concrete?
4. Will churned concrete in deep walls or columns bring up the scum, that is, the fine material of chalky nature?
5. Is there a layer of scum or dust on the joint?
6. Remove this scum.
7. If necessary, **pick** away the old concrete underneath the scum to find a clean surface.
8. **Wash** and **scrub** the exposed surface.
9. Why must the old concrete be wet?
10. Scrub in a **wash** of **neat cement** and **water.**
11. Deposit the new concrete in a thin layer before the grout has time to set.
12. Complete the concreting.
13. Consult advertising columns of technical press for patented preparations for uniting concrete surfaces.

Job Sheet No. 71

VOL. I, CHAP. XII, PAGE 317

STUDY WATERPROOFING OF CONCRETE

Water will usually enter concrete to some extent. Therefore, the term waterproofing concrete is not an accurate description. However, concrete may be made impermeable to all intents and purposes.

1. Select a piece of old dry concrete that you consider to be of good quality and examine it with a hand lens. Do you discover **pinholes** or **seams?**

2. What effects might the following have in producing these holes and seams:

   Excess water.
   Air bubbles.
   Shrinkage.

3. How may these defects be reduced?

4. Examine a concrete structure in your **vicinity,** a wall or arch bridge, and determine if water is **seeping** through.

5. How has the result of the flow shown itself? Is there evidence that the water has carried the cement from the interior and left it on the surface? How do you distinguish between this effect and **efflorescence?**

6. Is there a general **seepage** or a definite **flow** through a seam?

7. Is the seam a **crack** or the result of a **construction joint?**

8. What caused the crack, a **settlement** of the structure or a **shrinkage?**

9. Why is it necessary that a wall or an arch bridge should be impermeable?

10. What causes **dampness** on the inside of a cellar wall of concrete? Is it due to **condensation** or may the moisture come through the wall by **suction** or by **pressure?**

11. How would you remedy this trouble in a wall already built? How might it be prevented in the first place?

12. Look up the subject of **integral waterproofings** and state the purpose and the manner of action of these compounds.

13. Are these integral waterproofing substances needed if the concrete is dense and carefully made?

14. Look up the use of membranes for waterproofing.

15. A long slab roof, on columns, containing expansion joints covers a warehouse that must be dry. Draw a sketch showing how to waterproof the roof in general, and also at the expansion joints.

16. State how you would prepare the surface of the concrete roof for the waterproofing material.

17. A concrete tank with 16 feet depth of water, walls 4 inches thick, develops a leak due to a pocket of poor concrete. What final damage will this leak cause? State how you would stop up the leak.

18. Consult trade publications describing patented waterproofing compounds. See Report of Committee on Masonry, Trans. American Railway Engineering Association. Vol. 15, 1914, page 513.

SECTION VI

REINFORCED CONCRETE CONSTRUCTION — Sheets 80–90

Job Sheet No. 80

VOL. I, CHAP. VI, PAGE 118, FIGS. 56–59

STUDY REINFORCING OF COLUMNS

The rods in concrete columns help to carry **vertical loads,** and also take **bending** stresses.

A **concrete column** is not usually of greater length than **15 diam.**

1. If one panel of a building is heavily loaded, and the others are without load, will the stress be equal on the outside and on the inside faces of the column? How about a wall column? Where will the greatest stress be found? When a stiff enlarged head like that in a flat slab construction is bent by an unequally loaded panel, there may be tension on the outside face of the column. How would you reinforce the concrete at these places of excess stress?

2. If a portion of the column contains porous concrete what service will a column rod perform in this region?

Look up drawings of columns of the various types in standard text-books. See Fig. 59, Vol. I, Chap. VI, page 119.

3. What per cent of vertical steel is used generally? What per cent of spiral steel?

4. What are the spirals for? What is the minimum pitch? Of what kind of steel are the spirals made? How are they manufactured and shipped?

5. How are the spiral and vertical rods fastened together?

6. What thickness of concrete should be placed outside the steel?

7. Read the drawing of columns 1 to 6 in Sheet 6. What are the ties for? What is the per cent of vertical steel in relation to the area of the column inside the steel, that is the core?

8. What should be the minimum size of any concrete column?

9. What should be the maximum spacing of the ties?

10. How are the column rods from one story joined to the next column and where? How is the joint made?

11. What should be the minimum size of the column rods?

12. How are column rods joined to the footing?

If a testing machine is available, load a 2 by 4-inch wooden stud, 5 feet long, of green wood, as a column. Notice which way it bends and state why. Notice where the failure occurs. What is this due to?

Job Sheet No. 81

VOL. I, CHAP. VI, PAGE 122

DETERMINE WHERE TENSION AND COMPRESSION OCCUR IN THE CROSS SECTION OF A WOODEN BEAM TAKEN IN THE MIDDLE OF THE SPAN

NOTE. — This job leads up to the correct placing of reinforcing in a concrete beam.

1. Select two clear pieces of **straight-grained** wood and as nearly alike as possible, preferably yellow pine, each 2 by 2 inches by 24 inches long.
2. Dry one thoroughly and soak the other over night.
3. Cut a length of 4 inches from each.
4. Load the short pieces in a testing machine on their ends in compression until failure results. Sketch the appearance of the failure.
5. Is there a crinkling of the fiber and a wedge-shaped line of failure? See Fig. 29.

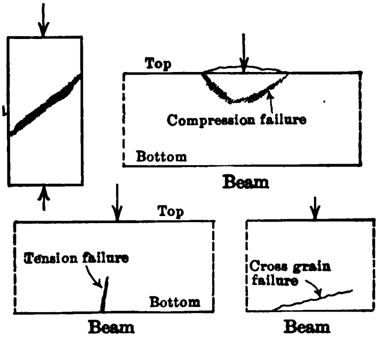


FIG. 29. APPEARANCE OF KINDS OF FAILURES IN WOOD.

6. What is the compression stress per square inch at failure?
7. How much stronger is the dry piece than the soaked piece?

8. Will a dry form be stronger than a wet form?

9. Place the dry and soaked 20-inch lengths separately in a testing machine as beams of 18-inch span. Load them in the middle to failure and note the amount of deflection at the center and the load. Sketch the failure.

NOTE. — The wet beam may be expected to fail in compression, and the dry beam may fail either in tension or in compression, depending upon the grain. See Fig. 29.

10. How much stronger is the wet beam than the dry beam?

11. Which bends or sags the more under an equal load?

12. Will a wet form sag more than a dry form?

13. What is the character of failure at the top and at the bottom of the wet piece? The dry piece?

14. What kind of stress does this indicate in each case?

15. Where would you put a steel rod to strengthen such a beam against tension failure if it were of concrete instead of wood?

NOTE. — Concrete is stronger in compression than in tension, — about ten to one. Wherever tensional stresses are expected in concrete steel rods are put in to tie the concrete together.

Consult Vol. I, Plate VI of Drawings of Lawlor Building, and find where rods are put in slabs.

Job Sheet No. 82

Vol. I, Chap. VI, Page 122, Figs. 60–62

ASCERTAIN THE PROPER LOCATION OF REINFORCING RODS AT THE MIDDLE OF THE SPAN OF A REINFORCED CONCRETE BEAM

These rods should be placed to strengthen the beam where tensional stresses are found. Mistakes have been made in laying reinforcement in the wrong portion of a beam.

Consult Fig. 30 which is a close-up view of the middle of a reinforced concrete beam that had been loaded at the center just above the crack, and supported at the ends.

1. What kind of stress or strain is indicated at the region of this crack?

2. Where would a rod be placed to best reinforce the beam in this region?

3. Would the rod be more effective near the bottom of the beam or near the center of the depth of the beam?

4. Does this stress diminish from the middle of the beam towards the ends?

5. Indicate by a line on this photograph the proper location of a reinforcing rod.

6. Consult Taylor and Thompson's "Concrete, Reinforced and Plain," and report if your sketch agrees with the drawings. Consult Vol. I, Figs. 78, 79, 81, 207, and Plate VI, for location of reinforcing rods. Read Vol. I, articles 60 and 61.

7. How far along the bottom of a beam should the rods extend toward the supports? Why are some of the rods bent up about the quarter point of the span and run to the top of the beam?

Perform the following job:

8. Make three concrete beams, A, B, and C, 4 by 6 inches by 3 feet. Place two $\frac{3}{8}$-inch deformed rods in bot-

tom of beam A, two bars in beam B at mid depth, and none in beam C. Cure these in moist sand.

9. When they have hardened 14 days, test them under a center load. Apply the load gradually, measuring the deflection until the maximum load is reached. Watch for

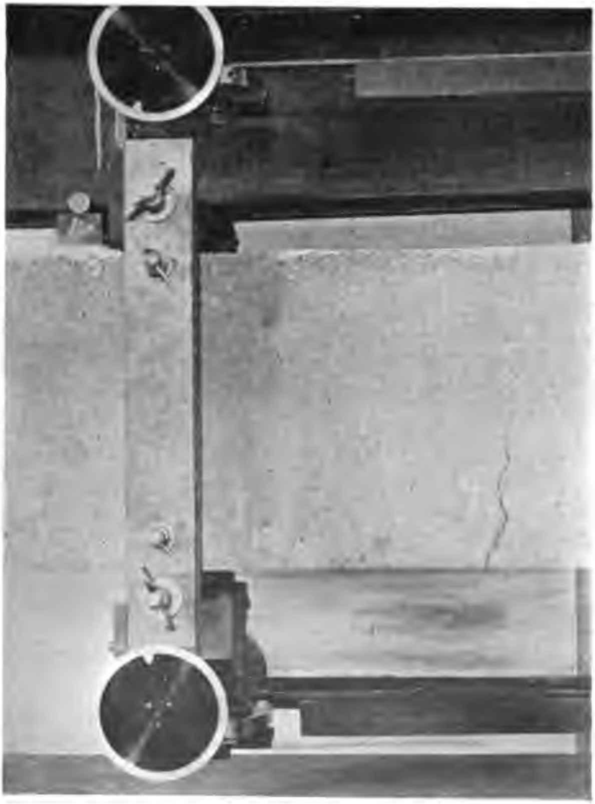


FIG. 30. PHOTOGRAPH OF THE MIDDLE PORTION OF A REINFORCED CONCRETE BEAM THAT HAS BEEN LOADED TO FAILURE.

The load was applied just above the crack. The dials shown are extensometer dials used for measuring the stretch in the bottom of the beam and the shortening in the top of the beam.

the appearance of fine cracks, and record the load and deflection of each beam at the appearance of each crack.

10. Fill out the following table:

	A	B	C
1. Beam..........................			
2. Load at first crack..............			
3. Load at maximum..............			
4. Deflection at first crack.........			
5. Deflection at maximum.........			
6. Ratio of loads 2.................			
7. Ratio of loads 3.................			
8. Ratio of deflections 4...........			
9. Ratio of deflections 5...........			

11. How much do the steel rods add to the strength of the beams?

12. Is a rod most effective at the bottom of the beam?

Job Sheet No. 83

VOL. I, CHAP. VI, PAGE 148

ASCERTAIN THE PROPER LOCATION OF REINFORCING RODS NEAR THE END OF A REINFORCED CONCRETE BEAM

Rods are bent up from the bottom of a concrete beam, and U-shaped stirrups are also used, to prevent diagonal cracks in the beam near the ends.

Consult Fig. 31 which shows a beam similar to that in Fig. 26, Job Sheet No. 82. The beam shown in Fig. 31 has failed near the end with a diagonal crack.

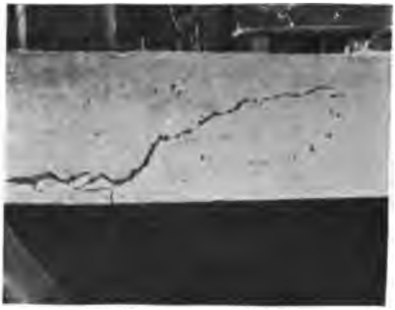


FIG. 31. PHOTOGRAPH OF THE PORTION OF A REINFORCED CONCRETE BEAM NEAR THE END, AND SHOWING A FAILURE BY A DIAGONAL CRACK.

1. Where would a rod be placed to strengthen the beam against this crack?
2. Could this be done by bending up one of the bottom reinforcing rods?
3. Sketch a beam with such a rod indicated.
4. Would a U-shaped rod, that is, a "stirrup," placed vertically in the beam in a transverse plane, also strengthen the beam against the diagonal crack?

5. Consult Taylor and Thompson's text and ascertain the kind and location of such reinforcing, referred to sometimes as "shear reinforcement." Consult Vol. I, Figs. 81 and Plate VI.

6. Which will act more effectively, a bent rod or a stirrup?

7. Should a stirrup be placed on top of or under the reinforcing bars in the bottom of the beam?

The tendency to form a diagonal crack increases the closer we come toward the support of the beam. Therefore these stirrups (see Fig. 81, Vol. I) are spaced closer at the end of a beam.

All concrete beams are reinforced at the middle of their span, but, generally, only those that are deep compared with the span are reinforced at the ends against diagonal cracks. The engineer determines when and how to reinforce such beams, and the concrete worker must follow his drawings.

Job Sheet No. 84

Vol. I, Chap. VI, Page 131

READ THE DRAWING OF SLAB REINFORCING, PLATE VI, PLANS, VOL. I

1. What is the load carried by this slab? What is the dead load of this slab? What is the span? How is it supported?

2. Why is the steel in the bottom of the slab at the center of its span?

3. What does the dotted line indicate?

4. Why does each alternate bar pass over the support on the top of the slab? (See § 61, Vol. I, Chap. VI, page 123.)

5. How many square inches of cross section of steel are there in the bottom of the slab per foot of width? What per cent of the cross section of the concrete is this? How much in the top?

6. Draw the shape of each bar. How would you make the bends?

7. Why is the bend made where it is shown?

8. How far from the lower surface of the concrete are the rods placed? How would you keep these in place while concreting?

9. What additional steel is placed in the slab and where? Is it shown?

10. How many pounds of steel per cubic yard of concrete in this slab?

Job Sheet No. 85

VOL. I, CHAP. VI, PAGE 131

READ DRAWING OF REINFORCED CONCRETE BEAM, PLATE VI, PLANS, VOL. I

1. Where is beam No. 5 shown on drawing? What does the horizontal line just below the top show? What is the 12-inch dimension below the beam?

2. How many beams of this size are there? What is the depth of slab adjoining?

3. How many rods in the bottom of the beam? What size? How many rods in the top over the column? Sketch the shape of each rod.

4. What are the stirrups or shear rods for? (See Job Sheet No. 83.) Why are they put at the ends, rather than at the center? Do they pass over or under the beam rods?

5. Why are some of the rods shown hooked at the end? (See Job Sheet No. 48.)

6. How far from the lower surface of the concrete are the bottom rods placed? How would you hold the rods in place while concreting?

7. What difference is there between beams 4 and 5?

8. What does beam 3 carry? What are its cross section and length and what supports it?

9. Where is beam 1 shown on beam 3? How many rods in the bottom of beam 1? Why are some of these bent? What do the dotted lines show?

10. Why are the stirrups spaced unequally in beam No. 1? (See Job Sheet No. 83.)

Job Sheet No. 86

Vol. I, Chap. VII, Page 148

READ DETAILS OF BEAM NO. 7, SHOWN ON PLATE VI, VOL. I

1. Are the bars shown with complete information for this beam in the elevation given on Plate VI?

2. Where is the necessary information given?

3. Could the details of this beam be drawn without the use of a beam schedule tabulated as shown on Plate VI? How?

4. Draw an elevation of this beam to ½-inch scale giving all necessary information on the detail. Keep this to the right of your sheet. At the left allow space for 2 sections, one taken outside of the curb of the louvre and one through the louvre.

5. Why do we need these two sections?

6. Would you repeat information given on the elevation on the sections? Which dimensions had better be on the sections? Which on the elevation?

7. Engineers sometimes draw all the steel in full heavy lines, separating the steel in the bottom layer so that it will show in elevation. Is this as good as the method given?

8. What objections could you offer to the method of indicating steel as given? Are they worth consideration?

9. Would you wish the lines showing stirrups as heavy as the lines showing the tension steel? Why?

Job Sheet No. 87

VOL. I, PAGE 9, PLATE III, PLANS

CONSTRUCT SKYLIGHT CURB AND PLACE WOODEN CURB PLATE

1. Make details of panels for the skylight curb beams for this building.
2. Construct the forms for same.
3. Place stop boards 4 feet from one corner in one direction and 6 feet from the same corner in the other direction.
4. Will you need templates for placing the anchors?
5. Will you place the wood curb plate when casting or later? Why?
6. Set the anchors and cast the curb.
7. Are your anchors straight? Are they uniform and in line?
8. Is the top surface of the concrete level and smooth? If it turned out rough, how would you set the plate? Why?
9. Will you counter-sink your bolts? Why?
10. Set the wall plate.

Job Sheet No. 88

VOL. I, CHAP. VII, PAGE 165, FIGS. 92 AND 93

STUDY EXPANSION JOINT IN ROOF BEAM

Expansion and contraction in concrete.

1. Concrete walls and slabs, without reinforcement, held rigid at the ends, usually **crack** open at intervals of about **30 feet,** due to **shrinkage** in hardening or to **contraction** caused by changes in temperature.

2. **Reinforcement** is placed in the concrete so that the movement may be taken up in the steel, thus **distributing** the large crack in the plain concrete among a **number** of very **fine cracks** throughout the surface of the reinforced concrete.

Would a long plain concrete wall crack if placed on rollers so as to be free to move?

3. Thin walls, curbs, and other structures may also **expand** under summer **temperature** and **buckle** out of line.

Beams and girders may **tear away** their seats on the abutments due to **contraction,** or may **spall** by **shoving** due to **expansion.**

4. Concrete when moistened swells, and on drying out contracts. It is like wood in this respect.

5. Therefore (see 1 to 4), the ends of girders, railings, bridges, floors, are provided with **expansion joints,** where **sliding** may take place.

6. Consult Hool and Johnson, page 554, and report how walls and buildings are provided with expansion joints, and pages 615, 619 and 623 for expansion joints in girders.

7. A movement of 0.0000062 may be expected for each degree Fahrenheit. This amounts to $\frac{7}{16}$ of an inch per 100 feet for a change of temperature of 60 degrees.

Roof of Lawlor Building

8. In the case of the roof of the Lawlor Building, will an expansion joint be needed?

9. Should such a sliding joint be placed at the ends of the slab and beams in the walls, or over the center columns?

10. Sketch a joint over the columns.

11. Consult Fig. 93 in text, page 165.

12. Should the joint continue into the slab?

13. What disposition should be made of the top steel in the beam at the joint?

14. Will a ½-inch joint be sufficient?

15. What material should be packed in the expansion joint?

16. What material should be used for the horizontal sliding surface at the joints?

17. How is this joint waterproofed and what provision is to be made for movement in the waterproofing device?

18. List material needed for this joint for full width of building.

19. What will be the action of the roof slab at the side walls?

Job Sheet No. 89

Vol. I, Chap. VI, Page 129

BENDING REINFORCEMENT

Consult "Concrete Engineers' Handbook," by Hool and Johnson, pages 139–142, and study methods and machines for bending reinforcement. (See also Fig. 67, Vol. I, page 130.)

Bend reinforcing bars for tile-joist slab in Job Sheet No. 90.

1. For this single job construct a stout table of 3-inch planks well cleated below as shown in Fig. 32. A 2-inch plank is nailed to the table to hold the bar in place. The steel plugs 4 to 6 inches long are fitted in holes bored in table to fix the points of bending, and sleeves are set over them.

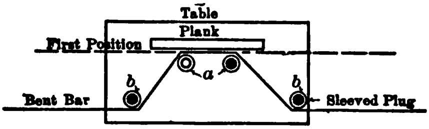


Fig. 32. Sketch of Apparatus for Bending Reinforcing Steel.

2. Fix the straight bar as shown in dotted line, Fig. 89b. Slip a piece of pipe over end of rod and bend it around plugs (*a*), and then around plugs (*b*). Why should the bend be made gradually and not with a jerk?

3. Is it necessary to bend the bar to a greater angle than shown to have it set at rest at the specified angle? Will this depend upon the grade of steel?

4. Is the grade of steel soft or hard?

5. Has any one of the bars cracked in bending? What would this indicate? (See Job Sheet No. 50.)

6. For what size bars is heat necessary to permit bending?

Does this depend upon the grade of steel also? How high may the bar be heated without danger of injury to metal?

7. Are the straight ends of the bar strictly parallel to the straight central portion?

Job Sheet No. 90

VOL. I, CHAP. VII, PAGE 144, FIG. 75

CONSTRUCT A ONE-WAY TILE AND JOIST SLAB

The 10-inch slab in the ground floor of the Lawlor Building is a solid concrete slab with ¾-round bars spaced 6 inches centers. This slab might be built in the hollow-tile reinforced rib construction. The hollow tile will act as fillers between the ribs, lighten the floor, simplify forms, and offer a good surface for holding plaster. The slab may be constructed of 8-inch tile spaced 16 inches, with 2 inches of concrete on top. The 4-inch ribs contain two ¾-inch rods, one straight and one bent.

Draw framing plan for this slab.

Construct this Slab

1. The form work is simple. 2 by 6-inch joists, spaced 16 inches on centers, support the tile and concrete. (See Fig. 75, Vol. I.) The planks are supported by 4 by 4-inch girts on 4 by 4-inch jacks spaced 3 feet centers. Are the jacks firmly wedged and on firm sills?

2. What is the difference between one-way and two-way tile? Which should be ordered? Sprinkle the tile. Why?

3. Lay the tile closely, end-to-end, with a 4-inch opening or channel between the sides to form the concrete rib or joist. Which is the more correct term for this, "rib" or "joist"? Close up openings in the end tile, and all openings due to breaks, with shingles of wood or tin, preferably tin. Why? The tile will not fit perfectly. How large an open crack would be allowed?

4. Set the reinforcing bars and support them in place as shown in your approved plans. How far should they be from the bottom of joist? Consult Vol. I, Fig. 69, page 131, for bar holders. The bent bar may be wired to a cross bar on

top of the tile, or to temperature reinforcement when this is called for. (See Job Sheet No. 41, Bending Reinforcement.)

5. Lay $\frac{1}{4}$-inch rods at 24-inch centers transverse to joists on top of tile for temperature and shrinkage reinforcement. This is not always necessary, but makes a better job.

6. Pour a wet mix of 1–2–4 concrete in the joists, cutting it around the bars, and bring it to full height. Strike off the surface.

SECTION VII

Sidewalk Construction — Sheets 100–107

Job Sheet No. 100

Vol. I, Chap. X, Page 256

STUDY ORGANIZATION OF A SIDEWALK JOB

1. Sketch an organization to show
   (*a*) Location of materials.
   (*b*) Distribution of gang.

2. Consider the following as a suggestion for a job, using hand work, no mixer being available:

   Four men shoveling gravel on the board, mixing, wetting and shoveling into forms.
   Two men excavating and tamping.
   One man mixing mortar for the top.
   One finisher.

3. Compare the organization as sketched by you with that by the foreman and report differences. Criticize your own plan.

4. Has the placing of the materials demanded unnecessary carrying and wheeling of gravel and cement?

5. Are they so related to the walk that they can be shoveled on the mixing board, and then directly in the forms?

6. Are all the men working efficiently and without waiting for each other, or interfering with each other?

7. Are the proper tools being used?

8. Calculate the quantities of cement, sand, and gravel needed for the job, and report how this agrees with what was found to be necessary.

Job Sheet No. 101

Vol. I, Chap. X, Page 217

STAKE OUT A SIDEWALK, EXCAVATE, AND BUILD FORMS

The job selected is 50 feet long, 5 feet wide, and 4 inches thick. The soil conditions are good. The various parts of the walk are shown in sketch.

Tools Needed: Shovels, pick, mattox, tampers, square, straight-edge, level, line.

See Fig. 33.

The **subgrade** is the **finished surface** of the soil after the excavation is complete. The **sub-base** is a **filling** of good porous material that is sometimes necessary on top of the subgrade to provide bearing and drainage when the subsoil is poor. The **base** of the walk is the concrete on which the

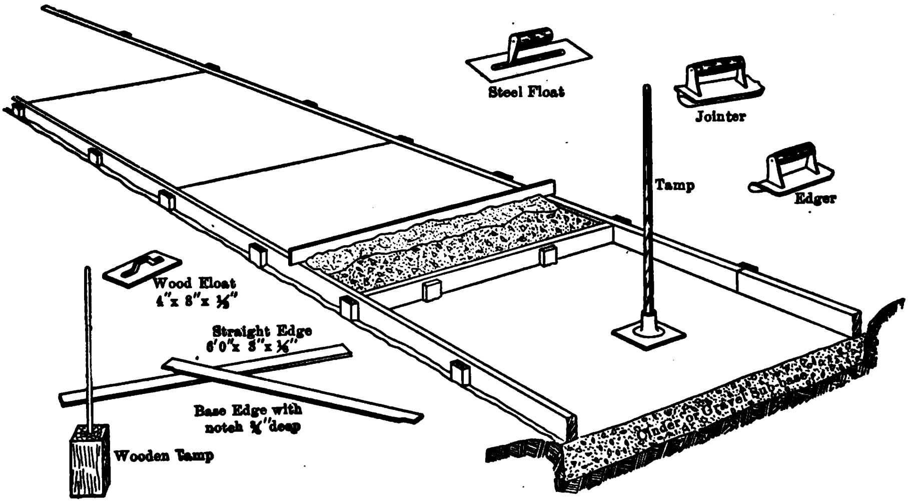


Fig. 33. Diagram showing Sidewalk Construction.

top is placed. The **top** is the wearing surface placed on the base and united to it.

The **base** should be **strong,** with clean aggregate so that the top will unite. The **top** should **wear** well. The **forms** should be **well braced** and **true** to **line,** so as to produce a workmanlike job. The concrete of the base is made rather dry, so as to permit the placing of the top and the removal of the forms within a short time.

An approved construction is to build only one course of full thickness, and finish a smooth wearing surface on this base.

1. **Stake** out the sidewalk.

2. Drive a stake at each end of the sidewalk, one foot back of the sidewalk line, and on these stretch a line on the grade of the surface of the walk.

3. Drive short stout stakes, about 4 feet apart, below the level of this grade line at a sufficient offset from the line of the edge of the sidewalk to allow for the side **forms.** Set a similar set of stakes on the other side of the walk. Will the finished width of the walk be five feet?

4. Which would be better, 1-inch lumber for the forms with the stakes closely staked, or 2 by 4-inch forms with stakes five feet apart? What would you do when the sidewalk was on a curve?

5. **Excavate** the **subgrade** approximately 4 to 13 inches deep depending upon the nature of the soil. **Tamp** the **surface** thoroughly. The subgrade should be of good material below loam. **Drainage** by tile may be necessary.

6. How far to one side should the dirt be thrown?

7. Has the subgrade been **tamped solid?** Have all soft spots been dug out, and filled in with good material and tamped? Are there **roots** that will heave the walk?

8. Does the foundation measure the **correct dimensions?**

9. Set the form lumber on one side with its top to grade and in true line.

10. Measure across five feet and set forms on other side of walk to true grade, using spirit level.

11. Are **side forms** properly **braced** and in **true line** and **grade?**

12. Are the **forms clean?**

Job Sheet No. 102

Vol. I, Chap. X, Page 217

(Study Article 128)

SET UP LEVEL INSTRUMENT AND READ LEVEL ROD

(See Figs. 150, 151, Vol. I, Page 230)

Equipment: Level, level rod, note book and pencil.

1. Set up the level. Is the base stable? Try shaking the instrument by means of leg of tripod. Is tripod screw tight? Is the tripod shoe set firmly in the ground?
2. Level the instrument.
3. How many leveling screws are manipulated at one time?
4. Can you level the instrument when the bubble tube is off the line of a pair of leveling screws?
5. How are leveling screws manipulated? Must they be turned through the same amount, both in or both out, in order to keep the bearing snug?
6. When the instrument is level, the bubble will remain at the center of its tube during a complete revolution of the telescope about the vertical axis.
7. Where are the cross-hairs located? What are they for?
8. If the image is not clear and distinct when sighting through the telescope move the focusing screw back and forth until the image is distinct.
9. Are the cross-hairs faint and hazy or clear? If not clear, manipulate the eyepiece.
10. Examine the level rod. What is the value of the smallest division on the rod? Where is the reading, at the top or bottom of the colored space? (See Figs. 154a, 154b, 154c, Vol. I.)

11. Find a point on the rod that represents a rod reading of 2.71, of 5.63, of 8.79.

12. What is "high rod"? "Low rod"?

13. With the image and cross-hairs clear and distinct, sight through the telescope toward the rod. Is the rod plumb? If not, what error will this cause? How can you tell if it is plumb in the direction of sight? Read the rod. (Check the bubble.) Is the bubble at the center of its run?

14. Record the rod reading in your book in feet, tenths and hundredths.

15. With the level and rod find the difference in elevation between two points on top of a curb. The two points should be at least 1000 feet apart.

16. Drive a stake at a distance of 100 feet from a curb. With the level and rod set the top of this stake at the same elevation as a point on the curb.

17. In determining differences of elevation between two points with a level, it is best to set up mid-way between the two points. This eliminates certain possible instrumental errors due to the non-adjustment of the level.

Job Sheet No. 103

VOL. I, CHAP. X, PAGE 234

ESTABLISH A CURB GRADE WITH LEVELING INSTRUMENT AND LEVEL ROD

Find the difference in elevation between a curb elevation and a man-hole and set curb stakes at a uniform grade.

Equipment: Level, rod, note book, pencil, elevation of bench mark.

Set up level in a position such that the B.M. and required points can be read.

1. A **bench mark** (B.M.) is a permanent point of reference for leveling operations. **Elevation** is the vertical distance of a point above a plane of reference, called the **datum plane.** (See Figs. 34 and 35.)

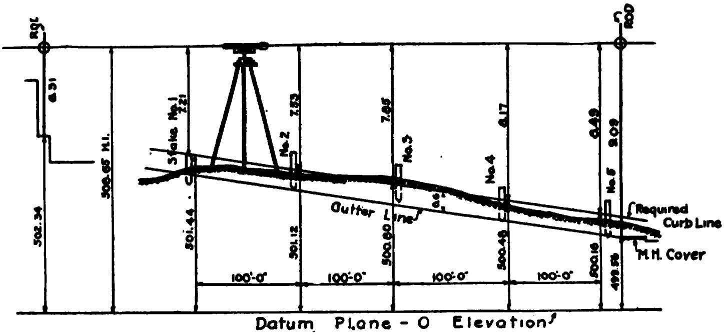


FIG. 34. DIAGRAM OF LEVELING OPERATION.
See Job Sheet No. 103.

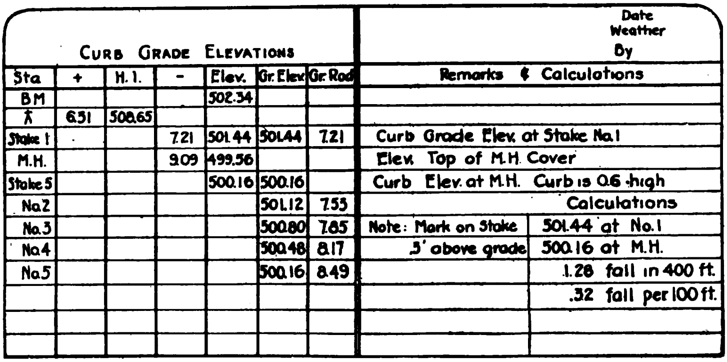
2. What is the elevation of the B.M. as obtained from the City Engineer? In the example this is 502.34. That is, the bench mark is 502.34 feet above the datum or reference plane.

3. Hold rod on B.M. and read the rod. (In example, 6.31.)

4. Compute the **height of instrument** (H.I.) for this set up. 502.34 + 6.31 = 508.65.

5. Hold rod on curb. Read it. In example this is 7.21.

6. Hold rod on curb stake No. 1. Move it up and down until it reads the same as on the curb, that is, 7.21.



CURB GRADE ELEVATIONS

Date
Weather
By

Sta	+	H. I.	-	Elev.	Gr. Elev	Gr. Rod	Remarks & Calculations	
BM				502.34				
⅄	6.31	508.65						
Stake 1			7.21	501.44	501.44	7.21	Curb Grade Elev. at Stake No. 1	
M.H.			9.09	499.56			Elev. Top of M.H. Cover	
Stake 5				500.16	500.16		Curb Elev. at M.H. Curb is 0.6 high	
No. 2					501.12	7.53		Calculations
No. 3					500.80	7.85	Note: Mark on Stake	501.44 at No. 1
No. 4					500.48	8.17	.5' above grade	500.16 at M.H.
No. 5					500.16	8.49		1.28 fall in 400 ft.
								.32 fall per 100 ft.

FIG. 35. NOTE BOOK RECORD OF LEVELING OPERATION.

7. Compute the elevation of the curb at stake No. 1. 508.65 − 7.21 = 501.44.

8. Read the rod on top of man-hole cover. In example 9.09. What should the rod reading be on the curb at this point?

Example. — Assume height of curb 0.06 foot. Rod on curb should be 9.09 − 0.06 = 8.49.

9. Compute the elevation of the curb at man hole. 508.65 − 8.49 = 500.16.

10. Compute the difference in elevation between curb at stake No. 1 and curb at man hole 501.44 − 500.16 = 1.28 feet.

11. Can this same difference be determined using only rod readings? In example, 8.49 − 7.21 = 1.28 feet.

12. The distances between stakes are 100 feet. Compute the curb grade elevations at stakes No. 2, No. 3 and No. 4.

Example. — Total fall in 100 feet = 1.28 feet.
fall in 100 feet = $\frac{1}{4}$ of 1.28 = 0.32 feet.
Curb grade elevation at stake No. 2 = 501.44 − 0.32 = 501.12.

13. Compute the rod reading necessary to establish a point on each curb stake at the required curb grade elevation.

Example. — At stake No. 2 curb grade elevation = 501.12.
H. I. = 508.65
508.65 − 501.12 = 7.53.

14. Hold the rod so that these computed rod readings are read by the instrument man at each stake and mark a line on each curb stake at the required grade elevation.

15. If instruction 14 is impossible, mark a line a definite distance above or below the required grade elevation. Record this distance in the notes.

Job Sheet No. 104

VOL. I, CHAP. X, PAGE 217

CONSTRUCT THE BASE TO SIDEWALK

(See Fig. 29, Job Sheet No. 101)

The base should be proportioned at least 1 : 2½ : 5. It is separated into blocks not over six feet long by construction joints so that subsequent movements will not permanently injure the walk.

1. Place a **cross form** to end a block, marking the location on the side forms.
2. Why will **frost** or **roots** of **trees** damage a walk less when it is divided into blocks?
3. What defects will come if the sub-base is tamped too little? If too much?

In foundations for **floors** and **sidewalks** on which a top is to be placed afterwards, the **concrete** is used fairly dry, about the consistency of **damp earth,** such that moisture will just flush to the surface after vigorous tamping.

4. **Place the concrete** in the forms to a depth of four inches and tamp to a depth of 3½ inches. **Strike off** with the **template** to an even surface.
5. Will moisture show on the surface of the concrete after tamping?
6. Will water appear on the surface when the concrete is struck with a shovel?
7. Which of these two consistencies is correct?
8. Has the tamping been thorough?
9. Will 5 inches tamped down to 4½ be a thorough job?
10. What trouble will come if the base is allowed to stand too long before the top is applied?
11. Remove cross form, and place the concrete for the next block to abut against the block just constructed. This

will form a **construction joint** along which the two blocks will not be united. When the top is finished a **groove** will be formed above this joint.

12. Another method is to build the walk in alternate blocks, leaving the cross forms in until the concrete has hardened somewhat. They are then removed and the connecting blocks built. Which of these methods is better?

13. Could this block method be used in case of wet concrete?

14. Concrete walks change length with the summer heat and the winter cold, and with alternate wetness and dryness of the concrete. **Expansion joints** are made to allow such movement, without buckling or cracking the walk.

15. Make an expansion joint every 25 feet by placing a $\frac{1}{4}$- by 5-inch strip between side forms. When concrete is laid and the top in place, remove the strip, and fill the joint with sand, or tarred felt.

16. Have dirt and dust blown on the surface of the foundation?

17. Has the foundation received its initial set before the top has been begun?

18. What is the longest time that should elapse between the tamping of the base and the placing of the top?

19. Sketch a diagram of the arrangement of materials and mixer or mixing board in relation to the foundation and report where labor could be saved in taking materials to the mixer or concrete to the foundation.

Job Sheet No. 105

VOL. I, CHAP. X, PAGE 220

PLACE AND FINISH THE TOP

Tools: Edger, jointer, trowels, wood and steel float, straight-edge.

See Vol. I, Chap. X, Figs. 142–146, page 221.

1. Is the **surface** of the base in good condition for placing the **top?** Has it **set** or is it **dirty?** Has **a scum** of fine material come across the surface? What would you do if these were found?

2. What is the purpose of the top?

3. The **top** or wearing surface should be **integral** with the **base** and of **strong dense mortar,** proportioned 1 : 2. The sand particles and not the cement must withstand the wear. As little cement as possible should be in the surface. The sand should be **hard** and **clean.** A gritty sand with little fine material will be harder to finish and will take more cement. The **mortar** should be **thoroughly mixed** with a hoe, or in a mixer, and should be of waxy consistency. Too little or too much water will cause wear. Why will long mixing detect the use of too much water?

4. **Place** the **mortar** on top of the base, and strike off with the **straight-edge,** with a transverse saw-like motion. Is there excess water on the surface? How would you get rid of this? When the mortar takes an initial set, **finish** the **surface** with a wooden float or trowel. See Vol. I, page 222, on the use of tools.

5. What change takes place in the appearance of the surface of the mortar at the initial set? (See Job Sheet No. 21.)

6. Learn the **art of finishing** the surface and handling the tools from the foreman or by experience.

7. Has your finishing work brought **excess water** to the surface, or **fine material?** What harm will this do? Is it

necessary to finish the walk to a very smooth surface? How would you remove excess water from the top? Will long troweling with steel trowel bring cement to surface?

8. How far ahead of the top is the base, in distance and time?

9. Cut through the top to the construction joint in the base, and run a jointer along this cut.

10. Remove the side forms, and finish the edges of the sides with an edger to a ½-inch radius.

11. Estimate the following for this job, for 100 feet of walk,

    Quantities of material in top and bottom.
    Hours of work of shovelers, finishers, etc.
    Other items of cost.

12. Estimate the cost of this work for the various items.

13. Consult the instructor, and estimate the cost of doing this work under usual conditions.

Job Sheet No. 106

Vol. I, Chap. X, Page 225

CONSTRUCT SECTION OF CURB AND GUTTER

1. Consult Section 8, Plate I, of plans of Lawlor Building for combined curb and gutter.

2. Would the design be improved if the outer face of the curb were curved? Why? (See Recommended Practice, Vol. I, page 250.)

3. Construct forms and proceed as directed in Vol. I, Chap. X, page 250. (See Fig. 147, Vol. I.)

4. What should be the consistency of the gutter and curb concrete? Like damp earth or a jelly-like mixture?

5. Why must the curb concrete be laid very dry? What difficulties would result from a wet mixture? (*a*) Additional forms? (*b*) finish? (*c*) subsequent expansion?

6. Will the granolithic stick better to a dry mix or the wet mix?

7. Will the granolithic surface be mixed as wet as for the sidewalk top?

8. Which will be the better curb — one cast wet with mortar cut to surface of forms, or a dry backing with plastered surface?

9. Inspect curbs in the vicinity and report if surface plaster comes off or if water gets underneath surface plaster. Does expansion show itself in spalling?

10. Would you recommend curb cast wet or one as described in text?

Job Sheet No. 107

VOL. I, CHAP. X, PAGE 280

PROPER CURING OF CONCRETE

Hardening of cement is **not** essentially **a drying out** process. **Water is needed** for chemical action, and this water must not be lost by evaporation in floors and walks. Warmth promotes hardening.

Demonstrate the relative strength of concrete when cured in the hot sun, in dry air, and in wet sand.

1. Make nine 2-inch cubes and nine tension briquettes of 1 : 2 plastic mortar. If laboratory is not available use prisms as directed in Job No. 17.
2. Allow set A to harden in damp sand, set B to harden in dry air of the laboratory, and set C to harden outdoors unprotected from the sun.
3. Test the strength of these cubes and briquettes at an age of 14 days and record the results.
4. Which set is the strongest?
5. Do these results show that the concrete should be protected and kept moist when hardening?
6. If one set of the specimens were stored in a cold moist place and another in a warm dry place which would be likely to develop the greater strength in 14 days?
7. Consult "Concrete Engineers' Handbook," page 211, and report what precautions are taken in construction to protect the concrete. Also Vol. I, pages 180 and 181.

SECTION VIII

PRODUCTS — Sheets 110–113

Job Sheet No. 110

VOL. I, CHAP. VIII, PAGE 182

FORM AND CAST A SILL AND FINISH IT

Artificial stones of concrete, if carefully made and of proper aggregates, can **replace** more **expensive cut stone.** This field of concrete products is attractive to the concrete worker. It demands skill and practice and understanding of principles.

For **forms** select a wood of a **smooth** surface, fine grained, preferably white pine or wood that **will not warp.** What difficulty would be met in hemlock? Have all **imperfections** and holes been **filled** with plaster? Are the **forms heavy** enough and **well-braced** to withstand tamping? What trouble will come if the bottom yields through lack of support?

JOB NO. 110 — PART 1

First Method of Casting for Facing

1. **Mix** the materials with unusual care to obtain **uniformity.**

2. Use a quaking concrete of 1 : 2 : 4 mix tamped into place. The coarse aggregate not to exceed $\frac{1}{2}$ inch in diameter. The fine aggregate should be coarse, not finer than $\frac{1}{16}$ inch in diameter. Let the top of the stone be up.

3. **Tamp** the concrete and **slice** it **back** from the face of the forms thus bringing the mortar to the surface. Strike off the top. There should be no free water.

4. When the concrete is sufficiently hard, after from 6 hours to 12 hours, depending upon the brand of cement and the weather, carefully **remove** the sides of the **form** and **scrub off** the surface with a dry scrub brush, followed by a **water spray.** This will remove the cement and expose the fine aggregate. Be careful to preserve the edges and corners of the stone from damage when removing the forms, which should be lightly tapped.

Read also Vol. I, Chap. VIII, paragraph 96, Figs. 106–109, on finishing.

5. Cover the stone with a **wet cloth** and allow it to **cure** for at least 14 days.

JOB NO. 110 — PART 2

(Figs. 102, 103, Vol. I, page 182)

Second Method of Casting, with Selected Facing

1. Place the forms so the **face** of the stone will be **down.**

2. Thoroughly mix the **facing material** of **selected fine aggregate,** fairly dry, the proportions 1 : 3. This **aggregate** should not contain any dust and not more than 10 per cent should pass on a number 100 sieve. For best results, to avoid crazing, fine **aggregate** should **not be finer than** $\frac{1}{16}$ **inch.** White cement with Crown Point Spar, which is a crushed light-gray granite, will give good results.

3. **Tamp the facing** on the bottom of the mold, then upon the sides and part way around the ends. Use the steel plate as shown in Fig. 189. Then follow with the backing concrete and tamp all thoroughly. **Strike off** the top and **bed a plank** on the top of the stone by means of a layer of sand.

4. **Clamp** this **top plank** to the bottom of the form and turn the whole upside down.

5. When the concrete is sufficiently hard, tap the molds gently and carefully remove the forms.

JOB No. 110 — PART 3

Third Method, Rubbed Surface

1. Allow the stone in Method II to harden longer, for a day or two. See that no wires project. **Point** any pockets or open places with 1:1 mortar, and let these patches harden 48 hours.
2. **Wash on** the surface of the stone a thin **grout** of 1:2 cement and sand.
3. **Rub** the **surface** with **a brick** of concrete, soft stone, or carborundum, with a circular motion until all marks are removed and the surface is of a uniform texture and color.
4. **Wash off** the grout.
5. Report which method gives (*a*) the best surface; (*b*) takes the least time.
6. This stone needs no finish. The stone must be **cured** under a wet cloth as before.

JOB NO. 110 — PART 4

Decorative Stone

White Portland cement may be used in either method and will give a very pleasing surface. This white cement costs from two to three times as much as ordinary cement. For special ornamental effects the facing material should be a colored aggregate used with the white cement. (See information on colored aggregates, Vol. I, page 187.)

An opportunity exists for the exercise of taste in design and coöperation between owner and worker in the construction of fireplaces and mantles of concrete, especially for summer cottages. Such concrete fireplaces cost only about half as much as fireplaces built out of field stone. For these concrete fireplaces artificial stones may be molded as described above and patterns or mosaics of select pebbles of various colors, such as are found on many beaches, may be set in the face of the stone. The rough concrete fire box and chimney may be faced with these artificial stones or they may be set in openings left in the rough concrete. The latter may be finished by method of washing.

The best pebbles are those of a smooth fine-grained surface that preserve their character when dry. Mosaic or patterns must not be spotted, but of a quiet tone or simple pattern. These patterns must be worked out in pebbles first of all, and are best arranged in a sand bed until satisfactory effects are secured.

The stone is cast by the First Method. The pebbles are quickly transferred to the top of the stone and hammered into place before the concrete has set. A heavy board is then tamped on the inserted pebbles to bring them to a uniform surface. The mortar will be nearly flush with the surface of the pebbles and should not show free water.

When the concrete has set for from 8 to 12 hours, the mortar is scrubbed and washed away to bring out the pattern. After final curing, a 1 : 3 solution of muriatic acid may be used to clean off any cement on the surface of the pebbles. Some pointing of the surface may be necessary.

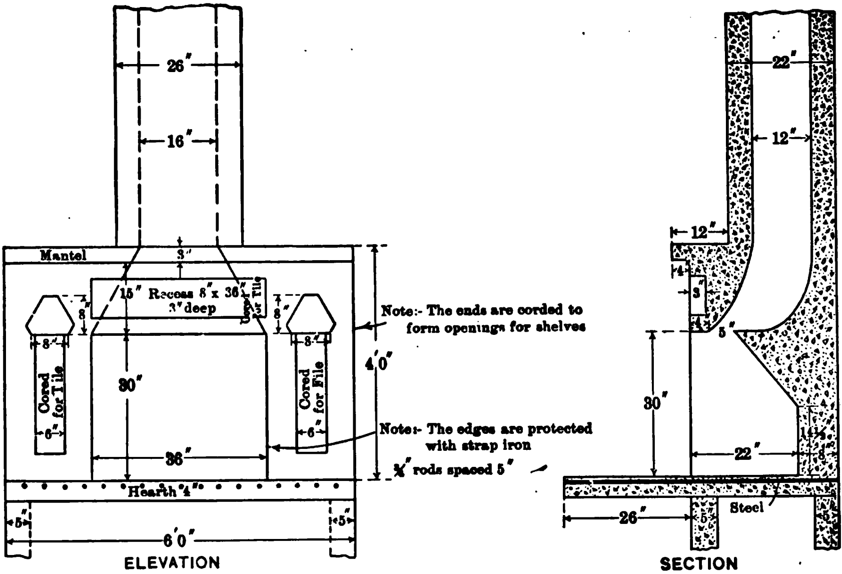


FIG. 36. CONCRETE FIREPLACE AND CHIMNEY FOR SUMMER COTTAGE.

The area of the throat should be ⅛th the area of the opening of the fire box. The edges of the opening are protected with strap iron set in the forms before pouring. Ornamental tile are set in the recesses. The hearth is cantilevered out. The exterior of the walls of fireplace and chimney has two layers of chicken wire to reinforce against cracking. For continuous use, the back of the fire box should be protected by fire brick. The chimney cost, in 1909, approximately $48.00. See *Cement*, Vol. IX, 1909, No. II.

Finally the luster of the stones may be brought out by the application of a little vaseline.

Rigid forms are particularly necessary.

If the top of the stone has become too stiff and the pebbles cannot be hammered in sufficiently deep they may be covered with a very rich mortar and later this can be washed away to expose the pattern.

The rapidity of the set of the cement should be known before any of this work should be started.

Job Sheet No. 111

Vol. I, Chap. VIII, Page 187

CONSTRUCT POST FOR PARAPET WALL OVER RETAINING WALL AND REINFORCE IT

1. Consult Vol. I, page 189, Fig. 111, for forms.

2. Bend a sheet of wire fabric to the shape of the post and set it inside the form with a clearance of 1½ inches from the form surfaces.

3. Mix concrete 1–2–4 to a medium wet consistency.

4. Pour the post, slicing the concrete well against the forms, so no patching will be required. After a day or two remove forms carefully to avoid spalling of corners.

5. If necessary, fill any pockets with 1 : 2 mortar, using the same sand. 48 hours afterwards, tool off any rough board marks and lumps to a fairly plane surface.

6. Rub surface with a brick of soft stone, carborundum or emery, using a circular motion, applying a thin grout of cement and sand (1 : 2) to the surface. This should be well rubbed in. If too much grout has been rubbed in in spots, remove this with a cork float.

7. Wash down the work with clear water.

8. Instead of rubbing as directed in (6), use a broom and a thin grout to smooth the surface, when green, allowing the straws to mark parallel lines on the surface.

9. Make another post with selected aggregate placed outside of the mesh as directed in Job Sheet No. 110.

10. Which of these three methods gives the best and most uniform appearance for the cost?

11. Concrete for posts must not be porous, otherwise the reinforcement will rust.

Job Sheet No. 112

VOL. I, CHAP. VIII, PAGE 182, FIGS. 104, 105

SAND-CASTING ARTIFICIAL STONE

Artificial stone is sand-cast to produce a sand finish. The stone is either poured into the **sand mold,** which is in a pit, or in a **wood box** (flask). The **model** is made first, either a box or a solid rectangular block, and is **bedded** into the sand and **tamped** solidly into place. In order that it may be drawn easily it must be provided with **tapered sides** (draft). The **insert molding** is then placed. The surfaces of the sand are coated with an integral waterproofing powder, such as Medusa.

1. The accompanying stone is to be used as a belt course stone.

2. What is the advantage of the insert? (See Fig. 37.)

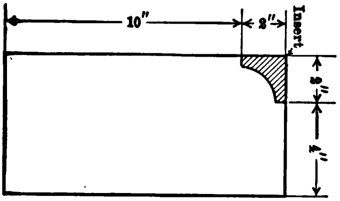


FIG. 37. INSERT FOR SAND-CASTING ARTIFICIAL STONE.

3. What kind of lumber would you use for an insert?

4. Construct a flask of 8-inch planking with internal dimensions of 24 by 36 inches. Construct a drag board or pallet of sheathing, cleated, and large enough to accommodate the flask (36 by 48 inches).

5. Construct a rectangular model 24 inches long and provided with an $\frac{1}{8}$ draft for the 6-inch dimension.

6. Will you construct a box or use a solid block? Why? Will you provide grips for drawing? Why?

7. If you had orders to make 20 such blocks, which would be the cheaper, to make separate wood molds or to use the sand-casting method? How many separate molds would you use? Would they be useful after the job is done? Would the flasks be useful after the job is done?

(Base this upon a base price of —

$60.00 per M for lumber
3.00 per yard for sand
15.00 per M for salvaged lumber, which is useless for future jobs.)

8. Set the drag board upon the ground. Place the flask upon the board. Spread a layer of sand about 2 inches deep in the flask. Set the model with the smaller face downward and tamp it solidly in place. Tamp sand around the model to the surface of the plank flask. Withdraw the model. Set the insert into the lower corner of the sand mold and tamp it gently into place. (See Fig. 32.) Oil the insert before placing. Sprinkle Medusa or some other integral waterproofing powder over the face of the mold. Mix the concrete rather wet and place it very carefully until the mold is level full. Level concrete off to plane surface.

9. Allow the concrete to set for 3 days and withdraw the flask and brush the concrete with stiff brush.

10. Would large stone be apt to disfigure the mold? Would ½-inch stone graded to ¼-inch be better to use? Would a mix of 1 : 2 : 3 be advisable? Why so much sand?

11. Note possibilities of disfigurement of mold, and repeat the job if the stone is badly marked. This work requires a great deal of experience.

Job Sheet No. 113

VOL. I, CHAP. XI, PAGE 287

PLASTERING

Methods of **plastering** and of applying **stucco** are now being carefully studied by experts, to prevent cracks and other failures.

The student will apply plaster to brick, tile, wood and metal lath vertical surfaces. This is a matter of experience and should be practiced for the purpose of determining quantities of materials required.

1. Estimate the amount of **cement, hydrated lime,** and **sand** required for the **scratch** and **finish coats,** on each of the various bases, per square yard.
2. Keep an accurate record of materials used. Compare with estimate. What percentage was necessary in addition? Would this be as large for experienced workmen? What percentage for waste would you advise in estimates?
3. Are **grounds** a necessary adjunct for plastering? Why? Can they serve more than one purpose? How?
4. What finishes are commonly used in plaster work?
5. Determine the time required for scratch and finish coats by observation on a going job in the vicinity.
6. Was the plaster too wet? Too dry? Determine the proper percentages of water for good working qualities. Draw your trowel through the mortar and develop the ability of determining proper consistency for working.
7. Slake some lump lime by adding enough water to just cover the lumps. Allow this to cool off before using and use it as a stiff paste.
8. Repeat a plastering operation with slaked lime instead of hydrated lime. Is there any difference in the working qualities? Why? Which is the cheaper to use?

SECTION IX

Walls, Etc. — Sheets 120–132

Job Sheet No. 120

Vol. I, Chap. IX, Page 197

BUILD A BRICK WALL AND SET WOOD FRAME

1. Draw up a plan and elevation for the first 17 feet of brick wall on the south building line from the west corner to ¾-inch scale. Indicate all brickwork and window (D).
2. What bond will you use for this brickwork?
3. Consult the specifications and determine upon the mortar.
4. Estimate the number of bricks and mortar required for this work if the erection is to proceed up to the meeting rail of the window on both jambs.
5. Make ¾-inch scale sections through the jamb and sill of the window.
6. What tools will you use in laying the brick?
7. Lay up 2 "leads" at either side of the construction to the 5th course. Then by the use of a mason's line set in the remaining bricks of the course.
8. How many inches of height are required for 5 courses? On this basis how many courses will be required to bring the brickwork up to the bottom of the sill?
9. Locate the two ends of the precast sill and set it using the end bending mortar and wood wedges. Is it level? Is the projection of the sill uniform?
10. Set the window frame. How will you brace it?
11. Lay up the jambs by the method of "leads" and fill as before.

12. Did you point your joints as you went along or did you delay too long? Which should you do? How?

13. Write a report on bricklaying from actual observation of a building in process of erection.

Job Sheet No. 121

VOL. I, CHAP. IX, PAGE 209

ERECT TILE WALL WITH DOOR FRAME

(Between Col. 3 and South Wall, Plate II)

1. What size of tile is required?

2. Will you set the tile with webs vertical or horizontal? Which is the better structurally? Will you need wire lath in the former case?

3. Set the door frame and brace it in place.

4. How many tiles will it take to erect the wall between Col. 3, Plate II, and the south wall of this building? How much mortar?

5. Set the end tile in last course before filling in. Erect these plumb and on line. Be sure each tile course is level as you go.

6. Erect the wall up to the head of the door. What is the size of a tile? How thick a joint will you use? How many courses will bring you to the top of the door?

7. Construct the reinforced tile lintel as discussed in Chap. IX, Page 211 Vol. I.

8. Have you provided nailing strips for fastening the door frame in both the jambs and the lintel?

9. Complete the wall.

Job Sheet No. 122

Vol. I, Chap. IX, Page 205

A STUDY OF STEEL SASH

1. How many kinds of steel sash are made? (See Sweet's Index.)

2. Discuss the essential differences, if any, between them?

3. What is the meaning of "X," "Y," "Z" in Fenestra sash?

4. If a steel sash has 14 by 20-inch glass, is five lights wide, six lights high, and has one centrally located ventilator of six lights, one light above the sill, how would you number it?

5. Study a "Truscon" or "Fenestra" steel sash catalogue.

6. How are the ventilators operated?

7. Where is the putty in a steel sash, inside or outside? Why?

8. Draw a full size section of a steel sash joint, sill, and head, in a 12-inch concrete wall.

9. Study the sections of the sash adjacent to the "vent." What difference in glass size is necessary in the "vent."

Job Sheet No. 123

Vol. I, Chap. IX, Page 213

BUILD WOOD PARTITION AND FIX METAL LATH

1. Study Plate XIII and Table XVII, page 138, Vol. I. Select a lath. Secure catalogue of this lath and determine recommended spans for studding and application.

2. Sketch the framing elevations of a 12-foot wood stud partition (blank wall) 16 feet long.

3. How much studding is required? How many nails and what size?

4. If both sides of the wall are to be plastered, how many square feet of lath will you order? (See Table XVIII, Vol. I.)

5. Erect the stud wall by setting the sill first. Then mark off the centers of all studs and cut same to length. Cut the plate for the partition. Tack the plate to the two end studs and raise into place. Brace and plumb these two studs accurately.

6. How will you provide for the stability of the partition after the braces are removed? (Partitions of this kind usually reach from floor to ceiling.)

7. Set the other studs, plumbing each as you go along. Could you have saved any time and studding by nailing all the studs to the plate before raising the partition? Is this good practice at times?

8. Apply the lath to the first six feet of one side of the partition, ready for plastering.

Job Sheet No. 130

Vol. I, Chap. XIII, Page 325

ESTIMATING

(These the student will work out under the direction of an experienced estimator. Study quantity surveys and the present method of determining estimates. The question of pricing can be taken up.)

1. Estimate the yardage of concrete in the foundations of this building.
2. Estimate the yardage of concrete in the reinforced columns, beams, and slabs of this building.
3. Determine the number of square feet of paving in this building.
4. Estimate the number of brick in the building.
5. Schedule the steel sash by number and type.
6. Schedule the wood sash and doors by number and size.
7. Estimate the tile required for the partitions.
8. Schedule all the steel for reinforcement.
9. Schedule all the steel for frames and lintels and also other light iron.
10. Schedule the number of squares (100 square feet) of roofing.
11. Schedule the skylights and louvre.
12. Schedule the wood blocks.
13. Schedule the linoleum.
14. Schedule the glass.

Job Sheet No. 131

VOL. I, CHAP. XIII, PAGE 335

WORK UP AN ESTIMATE SHEET FOR STEEL IN THE ROOF SLAB OF THIS BUILDING

(See Tables XXXVI, X, XIV, Vol. I)

1. What sizes of reinforcement are used?
2. How many divisions will be necessary under Column 5 in Table XIV?
3. Will you include roof beams in this estimate?
4. Make a rough take-off and check it.
5. Make your table and record the steel.
6. What is the tonnage?
7. What is the prevailing price of reinforcing to-day?
8. Price the slab steel.
9. Do bends make any difference in the price? How many bends are there in each of the bar sizes?

Job Sheet No. 132

VOL. I, CHAP. VI, PAGE 152

STUDY OF CONSTRUCTION PLANTS

(See Figs. 83, 84, 85, Vol. I)

1. List the equipment on each of these plants.
2. How does it compare with the yardage in each case?
3. What type of delivery seems to predominate?
4. Do railroad sidings play an important part in any of these plants? Why would this be important?
5. Is cement cheaper delivered on cars or by trucks to the job?
6. Would water transportation be important in any case?
7. Does lot area present an important feature? How? If you were limited for space in Fig. 83, how would you accommodate your towers?
8. Why does concrete placed 90 feet above the ground cost more per yard than concrete placed in the ground?
9. Report on the plant used on a nearby concrete building in process of erection. List all equipment, staging, and storage facilities.

INDEX

Abram, Duff A., Fineness Modulus, 51, 59, 68, 72, 83, 96, 98
Abscissa, 46
"Absolute voids," 88
Actual volume, 59
Age, effect on strength of cement, 47
Aggregate, absorption of, 69
  best coarse, 54
  change in volume of, 57
  coarse, 55
  coarse, surface area of, 92
  coarse, weight per cubic foot, 41
  colored, 180
  curve of, sieving test, 51
  determining weight of, 41
  examination of, 87
  fine, 55
  Fineness Modulus of, 99
  for structures, 55
  gradation of particles, 52
  "plant-mixed," 63
  procedure of examination, 87
  rules for usual cases, 74
  sample, test of, 48
  size and grading, 68
  specifications for, 55
  table of surface area, 96
  table of test results, 43
  water in, 69
  well graded, 52, 53
American Railway Eng. Assoc., 55, 141
American Society for Testing Materials, on lumber, 117
American Society for Testing Materials standards, 45, 50 (*see also* Year Book, 1916, D-7-16)
Amount of cement paste, 66
Analysis, mechanical, 50
Anchorage by hooks and bends, 108
Anchor bolts, 128
Apparatus for bending reinforcing steel, 157
Apparatus for weight per cubic foot, 41
Arbitrary mixes, concrete, 82
Arbitrary mix, proportioning by, 84, 90
Area (*see also* Surface area), 12, 13
  of circle, 13
  of parallelogram, 13
  of rectangle, 13
  of trapezoid, 13
  of triangle, 13
Arithmetical problems, 10
Artificial stone, 176, 184
  sand-casting, 184
Assembly of forms and details, 125
A. S. T. M. (*see* American Society for Testing Materials)

Ball-up, 33
Bank run gravel, per cent in sample, 49
  proportion of, in cement, 91
Bar holders, 159
Base edge, 162

Base, of sidewalk, 162, 170
  of testing machine, 27
Batch type concrete mixer, 130, 133
Batter, 15
Batter board, 19
Beams, concrete (*see* Concrete beams)
  details of, 153
  roof, 155
  wooden, 144
Beam yoke, testing machine, 27
Bench Mark (B.M.), 167
Bending apparatus, 157
Bending reinforcement, 157
Bending reinforcing steel, 157
Bending stresses, 142
Bending test of reinforcing steel, 110
Bends, anchorage by, 108
Best mixture, 92
Billets, 110
Bonding, 139
Bond, definition of, 106
  method of testing, 106
  of deformed bars, 109
Bottom lever, testing machine, 27
Box, measuring, construction of, 25
Bracing a trench, 21
Bracing materials, 21
Brick wall, 187
Briquettes, breaking of, 32
Buckling out, 155
Builders' hardware, article on, 115
Bulking effect of water, 57
Bureau of Public Roads, 37
Bureau of Standards, jigging table, 73
  flow table, 73

Calibration of tools, 25
Carload, 23, 29
Carrying wires, 112
Casting for facing, 177
Casting of facing, 178
Cast-sill, 5, 176
Catalogues of concrete mixers, 133
Cement and water, 66
Cement, amount of water for, 30
  early information on strength, 32
  increase in strength with age, 47
  normal consistency, 68
  procedure of mixing, 88
  proportioning, 91
  sampling of, 29
  storage house for, 23
Cement testing, consistency of mix, 30
  soundness, 31
  strength, 31
  time of set, 31
Chanelath fabric, 113
Changes in volume, 57
Channeled sample, 62
Chimney for summer cottage, 181
Circle, area of, 13
Cleanness, importance of, 33
Clinton wire cloth, 112
Coal chute, 138
Coarse aggregate, 55
  surface area of, 92
  weight per cubic foot, 41
Coating, 34
Colored aggregates, 180
Colorimetric test, 34
Columns, reinforcing of; 142
Combined volume of real mix, 103
Compacting by ramming, 58
Comparison of deformed bars, 109
Compound lever, testing machine, 28
Compression failure, 144, 145
  in wooden beam, 144
Compressive strength, and Fineness Modulus, 99
  of concrete, 69, 103

Computing quantities, 14
Concrete, appearance in slump test, 72
  bonding new to old, 139
  cause of poor, 67
  compression *vs.* tension stresses, 145
  compressive strength, 103
  consistency for road work, 48
  consistency measurement, 73
  consistency of, 70
  correction of, 132
  curing, 175
  curve of strength, 69
  degree of wetness for different purposes, 129, 170
  dry, 129
  for different purposes, 65
  for posts, 183
  Iowa Commission Standards, 85
  machine-mixed, 64
  mixing by hand, 64
  mixing of, 65, 131
  proportioning by surface area, 93
  proportions in, 77
  quantities required, 59
  reinforcement, 112
  relative consistency of, 103
  relative strength of, 78
  rods in, 105
  sign of too little sand, 65
  sign of too much coarse aggregate, 65
  specifications, 94
  strength of, 48, 75, 99
  testing machine for, 26
  test results, 86
  too dry, 48
  too little water, 67
  too wet, 48
  waterproofing, 140
  weakening factors, 66
Concrete, wet, 135
  workability of, 65
  yield of, 59
Concrete beams, 146, 149
  failure of, 147, 149
  reinforcing, 144, 146, 150, 152
Concrete columns, length of, 142
Concrete cylinder, testing machine, 106
Concrete Engineers' Handbook, 33, 34, 135, 155, 157, 175
Concrete fireplace and chimney, 181
"Concrete Foundations," a pamphlet, 123
Concrete mixer, 130
  catalogues, 133
  Koehring's, 133
Concrete mixes, design of, 103
Concrete mixes, proportioning of, 82
  by arbitrary mixes, 82
  by Fineness Modulus, 83
  by method of Iowa Highway Commission, 83
  by surface area, 83
  by void measurement, 82
  recommendations, 84
  to fit an ideal curve, 83
  sand required in, 100
Concrete road, 73
Concrete stairs, form details for, 122
Concrete steps, 6
Concrete, study of, 68, 69
  absorption of aggregate, 69
  consistency desired, 68
  proper size and grading, 68
  richness of mix, 68
  water for mixing, 68
  water in aggregate, 69
Concrete, theory of, 66
  amount of paste, 66

Concrete, cement and water, 66
  limit of surface area, 67
  quality of paste, 66
  rule for consistency, 67
  thorough mixing, 67
  weakening factors, 66
Concrete walls, cracking of, 155
Cone test, to avoid sticking, 72
Cone, volume of, 13
Consistency of concrete, 68, 70
  measurement of, 73
  relative, 103
  rule for, 67
Consistency, study of, caution, 74
  cone test, 72
  jigging table test, 73
  lubrication effect, 70
  measurement, 71
  slump test, 71
  specifications, 73
  workability, 70
Construction joint, 171
Construction, of measuring box, 25
  of mixing platform, 24
  of sidewalk, 162
Construction plants, 194
Continuous type concrete mixer, 133
Contraction, 155
Correction of concrete, 132
Corr-Mesh fabric, 113
Cover, frame for, 138
Cracks in beams, how to prevent, 149
Cross form, 170
Cross grain failure, 144
Cross sections, 9
Crum's method of proportioning, 83
Crusher-run stone, per cent in sample, 49
Curb grade, 167
Curb line, 167
Curb plate, 154
Curb, section, 174
  skylight, 154
Curing of concrete, 74, 175, 179
Curve, composition of gravel and crusher-run stone, 49
  composition of sand, 48
  Fineness Modulus and compressive strength, 99
  ideal, for concrete mixes, 83
  log scale, 51
  price of lumber, 46
  strength of cement, 47
  strength of concrete, 48
  water ratio in concrete, 69
Curve plotting, 46
Curves, of quantity of sand in concrete, 100
  of surface area of gravel, 95
  of surface area of sand, 94
Cut-off, 26, 27
Cutoff trigger, of testing machine, 27
Cut stone, 176
Cylinder, concrete, of testing machine, 106
Cylinder, volume of, 13

Datum line, 167
Decantation test, 37
Decorative stone, 180
Definition of sand and pebbles, 87
Deformed bars, comparison of, 109
  forms of, 109
Department of Agriculture, 61
Determination of silt, 36, 37
Determining weight of aggregates, 41
Diagonal crack, failure by, 149, 150
Diagrams (*see* Curves)

Differences of elevation, determination of, 166
Disfigurement of mold, 185
Distribution of particles, 47
Door frame for tile wall, 189
Dowel placing, template for, 127
Dowels, use of, 127
Draft, 184
Drag board, 184
Drainage, 163
Drawing, projection, 3
Drawings, reading of, 6
  of Lawlor Building, 16
Drum type batch mixer, 130
Dry beam failure, 145
Ductility, 110

Edger, 162
Edwards, 57
Elastic limit, 110
Elevation, 167
Elevation, front, 3, 4
  side, 3, 4
Elongated pieces in gravel, 56
Embedded bar, testing machine, 106
End brace, 31
Engineering News-Record, 73, 92, 94, 95
Equipment, for leveling, 165, 167
  for sampling, 61
  for void measurements, 87
Estimate for roof slab, 193
Estimating, 192
  form lumber, 119
Examination of aggregate, 87
Excavation, method of staking out, 19
  sidewalk, 162
  problems, 14
Exercises, in mensuration, 12, 13
  in reading drawings, 16
Expanded metal fabrics, 113
Expanding metal, method of, 112
Expansion joint, 155, 171

Fabric reinforcement, 112
Fabrics, expanded metal, 112, 113
  "self-sentering," 113
  wire, 112
Facing, 177, 178
Failure of concrete beams, 145, 147, 149
Failures in wood, 144
Fence post, 5
Fenestra sash, 190
Fine aggregate, 55
Fineness Modulus (F.M.), 51, 59, 68, 72, 83, 96, 98, 100, 103, 104
  of concrete mixes, 83
  proportioning by, 98
  relation to strength, 99
  value of, 104
Finish, of sill, 176
  of top, 172
Finish coat, 186
Finished surface, 162
Fireplace for summer cottage, 181
Flask, 184
Flash set, 31
Float, steel, 162
  wood, 162
Flood stage, 57
Flow tables, 73
Footing, stepped, 8, 126
Form for sill, 176
Form lumber, estimating of, 119
Form work, 159
Forms, cost of, 117
  details of, 122
  for artificial stone, 176
  lumber for, 117
  non-warping, 176
  sidewalk, 162
  treatment of, 118

Forms, two-wall, 123
Foundation, wall, 129
Foundation wall, trench for, 19
Frame, for brick wall, 187
  for cover, 138
  for tile wall, 189
Front elevation, 3
Front standard, testing machine, 27
Fuller's rule, 15, 59

Girts, 159
Gradation of particles, 48, 49, 52
Grade, curb, 167
Grading, of aggregate, 68
  of pit-run gravel, 95
  of pit-run sand, 94
  relation to surface area, 94
Granites, 69
Graphical representation (*see* Curves)
Gravel, measuring voids in, 38
  per cent in sample, 49
  specifications of, 56
Gravel concrete, proportioning of, 85
Gravel pit, report upon, 61
  sampling of, 61
  test of sample, 62
Gravel, road, 37
Gravel screenings, 55
Groove, 171
Grounds, 15, 186
Grout, 179
Gutter line, 167
Gutter, section of, 174

Hardening of cement, 175
Hard grade steel, 110
Hard set, 31
Harsh working, 65
Havemeyer bar, 109
Height of Instrument (H.I.), 168
Hollow tile, 159
Hooks, anchorage by, 108
Hool and Johnson, 33, 155, 157
Hydrated lime, 186
Hydro-Electric Commission of Ontario, specifications, 93
Hypotenuse, 12
Hy-Rib fabric, 113

Ideal curve, concrete mixes, 83
Impermeability of concrete, 140
Impurities, failure from, 33
Indiana State Highway Commission, specifications, 73, 114, 131
Insert for sand-casting, 184
Inspection of concrete mixers, 133
Instructions, for concrete test, 105
  for void measurement, 87
Integral waterproofing, 141
Iowa Highway Commission, 83, 84

Jigging table, 73
Jointer, 162
Joint, expansion, 155
Joist slab, 159

Kidder, "Building Construction and Superintendence," 115
Kinds of failures in wood, 144
Koehring concrete mixer, 133

Laitance, 139
Lath, metal, 191
Lawlor Building, concrete steps, 6
  drawings on, 16, 145
  forms and details, 125
  roof of, 155
  ten-inch slab in, 159
"Leads," 187
Leveling, equipment for, 165, 167
  instrumental errors, 166
  record of, 168

Leveling instrument, 167
Level rod, 165, 167
Lewis Institute, 69, 98
Limit of surface area, 67
Link, testing machine, 27
Lintel of reinforced tile, 189
Location of rods, 146, 149
Logarithmic scale plot, 51
Louvre, 153
Lug bar, 109
Lumber for forms, defects of, 117
  estimating of, 119
Lumber, variation in price of, 46
Luster, 181

Machine base, 128
Machine-mixed concrete, 64
Machinery for wood working, 120
Materials for void measurement, 87
Measuring box, construction of, 25
Measuring, necessity for, 25
Measuring voids in gravel and stone, 38
Medusa waterproofing, 184
Membranes for waterproofing, 141
Mensuration, 12, 13
Meshes of standard screens, 50
Metal lath, 191
Method, Crum's, 83
  of bracing a trench, 21
  of casting, No. 1, 177
  of casting, No. 2, 178
  of casting, No. 3, 179
  of decantation, 37
  of determining silt, 36
  of determining weight per cubic foot, 41
  of excavation, 19
  of expanding metal, 112
  of proportioning, 83
  of sieving, 44
  of testing bond, 106
Method of testing sieves, 45
  of washing, 34
  safe, 84
Mistakes in reinforcing, 146
Mixing, by hand, 64
  cement and aggregates, 88
  of concrete, 67
Mixing board, 64
Mixing concrete, 131
Mixing platform, construction of, 24
Moisture, 25, 38, 69
Mold for test pieces, 76
Mortar for sidewalk tops, 172
Mosaic, 180
Muncie Normal Institute, 26

Nails, varieties of, 115
Neat pat, 30
Note-book record, 168

One-way tile slab, 159
Ordinate, 46
Organic matter in silt, 33
Organization of sidewalk job, 161
Origin, 46
Ottawa sand, 35
Output, laborers', in shoveling, 18

Pallet, 184
Panel details, 126
Panel, wall, 5
Parallelogram, area of, 13
Parapet wall, 183
Partition, wood, 191
Paste, cement, amount of, 66
  quality of, 66
Patterns, 180
Pebbles, per cent, in sample, 57
  water holding capacity, 57
Pennyweight, meaning of, 115
Percentage, 10
Piling, 21

Pit-run gravel, grading, 95
Pit-run sand, grading, 94
Plain wall, 135
Plane of reference, 167
Planer base, 128
Plan projection, 4
"Plant-mixed" aggregate, 63
Plants, construction, 194
Plastering, 186
Plaster filling, 176
Plate, curb, 154
Platform of testing machine, 106
Plot on logarithmic scale, 51
Plots (*see* Curves)
Plotting of curves, 46
Plumb bob, 19
Pockets, 179
Pointing, 179
Portland cement, 35, 180
Post, for parapet wall, 183
Price of lumber, variation in, 46
Prism, volume of, 13
Problem in void testing, 39
Problems, arithmetical, 10
  excavation, 14
Projection drawings, 3
Preparations, patented, for bonding, 139
Proportioning, by arbitrary mix, 90
  by Fineness Modulus, 98
  by surface area, 92
  law of, 83
  of cement, 91
  of gravel concrete, 85
  procedure of, 85

Quality of cement paste, 66
Quantities, computing, 14
Quantity of sand in concrete, 100
Quartering, 36, 62
Quartering machine, 62

Ramming, compacting by, 58
Rear standard, testing machine, 27
Recommendations, concrete mixes, 84
Record, of beam test, 148
  of leveling operation, 168
Rectangle, area of, 13
Reinforcement materials, 114
Reinforcing, of columns, 142
  of posts, 183
  of slab, 151
Reinforcing rods, 146, 149
Reinforcing steel, test of, 110
Report upon gravel pit, 61
Representative sample, 52
Rerolled steel, 110
Resistance to pull, test of, 105
Retaining wall, 15
Reticulated sheet, 112
Rib, 159
Richness of concrete, 59, 68
Rigid forms, 181
Road gravel, 37
Rods in concrete, 105
Roof beam, 155
Roof slab, estimate for, 193
Ro-Tap machine, 45
Rough measure, 38
Rubbed surface, 179
Rubbing of surface, 183
Rule for consistency of concrete, 67
Rules, for figuring quantities, 59
  for usual cases, 74

Samples, test of, 41
Sampling, of cement, 29
  of gravel pits, 61
Sand, coarse *vs.* fine, 80
  in gravel, effect of, 91
  per cent in sample, 51
  quantity in concrete, 100

Sand, "sharp," 56
  sieving test of, 48
  surface area of, 92
  test for cleanness, 33
  weight per cubic foot, 41
Sand-casting artificial stone, 184
Sand mold, 184
Sand, pit-run, grading of, 94
Scale, logarithmic, 51
Scale, use of, 1
Scratch coat, 186
Screens, standard, 50
Scrubbing off, 177
Scum, 74, 139
Section, of curb, 174
  of gutter, 174
Self-sentering fabrics, 113
"Sharp" sand, 56
Shear reinforcement, 150
Sheet piling, 21
Short span slabs, 112
Shoveling, determination of laborers' output, 18
Shoving, 155
Shrinkage, 57, 59, 155
Shrinkage reinforcement, 160
Side elevation, 3
Sidewalk, approved form of construction, 163
  base to, 170
  excavation for, 162
  forms for, 162
Sidewalk construction, tools for, 162, 172
Sidewalk job, organization of, 161
Sieve analysis, 46
Sieves, method of testing, 45
  standard, A. S. T. M., 45
  study of, 44
  Tyler series, 44, 51
Sieving test, 48
  of gravel and crusher-run stone, 49
Sieving test, of sand and pebbles, 51
Sill, casting of, 176
  finish of, 176
  form for, 176
  projections of, 3
Silt and clay, 33
Silt, maximum permissible, 34
  methods of determining, 36
  volume *vs.* weight, 34
Size, of aggregate, 68
  of particles in aggregate, 52
Sizing of particles in aggregate, 48, 51
Skylight curb, 154
Slab, construction of, 159
  joist, 159
  reinforcing of, 151
Slag aggregate, weight of, 42
Slicing, 177
Sliding, 155
Slip, in concrete, causes of, 106
Slump test, apparatus for, 71
  appearance of concrete in, 72
Sodium hydroxide, 34
Soil, yielding, 21
Soundness, definition of, 31
Spalling, 155
Span, 144, 146
Specifications, American Railway Engineering Association, 55
  for aggregates, 55
  for mixing concrete, 131
  of concrete, 94
  of reinforcing materials, 114
  State Highway Commission, 55
Specimen for test, 26
Sphere, area of, 93
  volume of, 13
Spreader, 21, 31
Spring block, testing machine, 27
Stairs, concrete, form details for, 122

Staking out, for foundation wall 19
  for sidewalk, 163
Standard screens, 50
Standards, front and rear, of testing machine, 27
State Highway Commission, 55
Steel float, 162
Steel rails, 110
Steel, reinforcing, apparatus for bending, 157
Steel sash, 190
Stepped footing, 8, 126
Steps, concrete, 6
Sticking of concrete, 72
Stirrups, use of, 149
Stone, artificial, 184
  crusher-run, per cent in sample, 49
  decorative, 180
  measuring voids in, 38
Stop board, 137
Storage house for cement, 23
Straight edge, 162
Strength, of cement, 47
  of concrete, 48, 68, 69, 75, 78
  of mortars, 36, 80
  relation to Fineness Modulus, 99
Strength test, 31
Striking off, 170, 178
Structural grade steel, 110
Structural Materials Laboratory, 69, 98
Stucco, 186
Stud wall, 191
Sub-base, 162
Subgrade, 162
Surface area, calculation of, 93
  increase of, 92
  example of method, 96
  limit of, 67
  of coarse aggregate, 92
  of concrete mixes, 83
Surface area of gravel, 95
  of sand, 92, 94
  proportioning by, 92, 93, 97
Sweet's Index of steel sash, 190
Swelling, 155

Table, A. S. T. M. sieve series, 45
  grading test, 52, 53
  mechanical analysis, 50
  of surface area, 92
  surface area of aggregate, 96
  Tyler sieve series, 44
  Tyler standard screens, 50
Tamp, 162
Tamping, 72
Taylor and Thompson, 61, 88, 146, 150
Tearing away, 155
Template for dowel placing, 127, 170
Temperature, effect of, 155
Temperature reinforcement, 112, 160
Tensional stresses, 146
Tension in wooden beam, 144
Tension failure, 144, 145
Test, of anchorage, 108
  of particles in aggregate, 52
  of reinforcing steel, 110
  of resistance to pull, 105
  of voids, 39
Testing of cement (*see* Cement testing)
Testing of gravel pit sample, 62
Testing of sand, by strength of mortar, 35
  colorimetric, 34
  for cleanness, 33
  results, 36
Testing machine, 27, 28, 106
Testing machine, home-made, 26, 27

Test pieces, 31, 32
  for home-made machine, 81
  mold for, 76
Test results, grading, 52, 53
Test samples, 41
Thorough mixing of concrete, 67
Tile, one-way, 159
Tile wall, 189
Time of set, 182
"Tolerance," 56
Tools, calibration of, 25
  for concrete work, 120
  for sidewalk construction, 162, 172
  for wood working, 120
Top finish, 172
Top, of sidewalk, 163
  of testing machine, 27, 28
Top lever, testing machine, 27
Torpedo sand, 34
Training Manual for Concrete, 26
Transactions American Society for Testing Materials, 57
Transverse reinforcement, 112
Trapezoid, area of, 13
Traps, 69
Trench, bracing of, 21
  excavating of, 19
  in yielding soil, 21
  for foundation wall, staking out, 19
Triangle, area of, 13
  use of, 1
Trigger, testing machine, 27
True line, 163, 164
Truscon sash, 190
T-square, use of, 1
Two-wall form, 123
Tying, 112
Tyler sieves, 44, 50, 51, 62

Ultimate strength, 110
Uniform methods, importance of, 30
U-shaped rods, 149

"Vent," 190
Vertical loads, 142
Void measurement, proportioning by, equipment, 87
  examination of aggregate, 87
  instructions, 87
  materials, 87
  mixing cement and aggregate, 88
  unreliability of, 83
Voids, measuring of, 38, 39
Volume, of cone, 13
  of cylinder, 13
  of prism, 13
  of sphere, 13
  of wedge, 13
Volume, change in, of aggregates, 57
Volume, combined, of real mix 103
Volume, loose and mixed, 57

Wale, 21, 31
Wall, brick, 187
  parapet, 183
  plain, 135
  retaining, 15, 183
  tile, 189
Wall form, stop board in, 137
Wall foundation, 129
Wall panel, 5
Warehouse set, 23
Washing test, 37
Water, effect of, 48, 57, 67
  for mixing concrete, 68
  importance of, 78
  in cement hardening, 175
Water and cement, 66
Water-cement ratio, effect of, 68

Waterproof building, 23
Waterproofing, 140
Waterproofing compounds, 141
Water ratio in concrete, curve of, 69
Water spray, 177
Weakening factors in concrete, 66
Wedge, volume of, 13
Weight per cubic foot, 8, 11, 41, 42
  method of determining, 41
Welding, 112
Wet beam failure, 145
Wet cloth, 177
Wheelbarrows, 18, 25
Williams' Flow Table, 73
Wire fabrics, 112
Wooden beam, compression in, 144
  tension in, 144
Wooden tamp, 162
Wood float, 162
Wood frame for brick wall, 187
Wood partition, 191
Wood working, machinery for, 120
  tools for, 120
Workability of concrete, 65, 74
Wrapping, 112

Yielding soil, 21
Yield of concrete, 59
Young, R. B., 92, 94, 95

NOV 4 1921